MACHINERY.

February, 1906.

# THE COLBURN MACHINE TOOL COMPANY'S SHOP.

## DETAILS AND SPECIFICATIONS.

In the December number of MACHINERY were published details and specifications of a modern, mill-type building, and it was announced that we should later publish details and descriptions of several modern plants of medium size of other types of construction. We believe that information of this character will be appreciated by many who are investigating shop architecture. For the subject this month the new shops of the Colburn Machine Tool Co., Franklin, Pa., have been selected; they are an excellent example of what may be termed the standard type of steel construction in which there is a high runway or erecting floor down the center of the shop, with wings on either side for the smaller tools. We publish in this connection partial specifications of the plant and detail drawings of the most important features of construction.

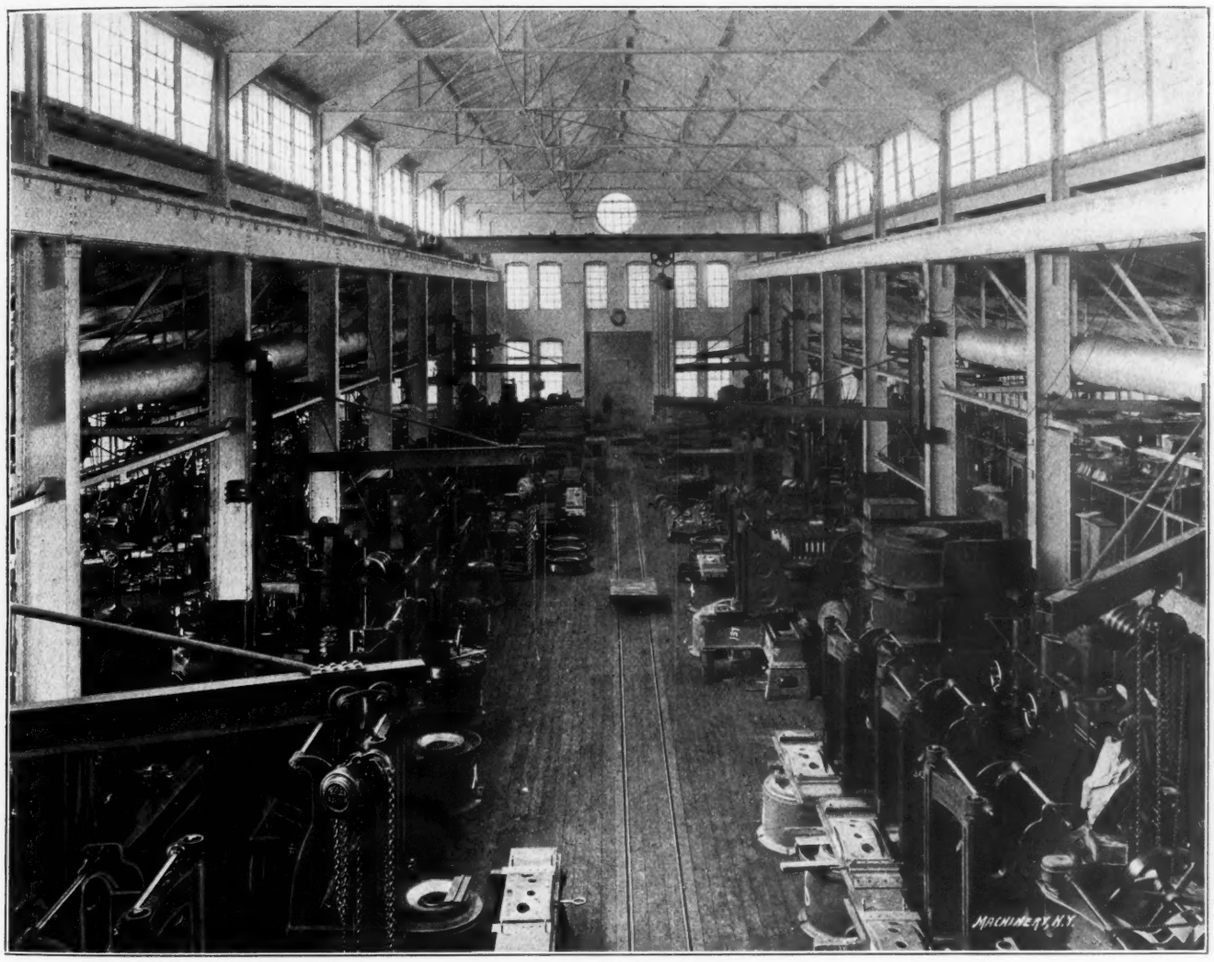


Fig. 1. Interior of Machine Shop.

The plant was completed in 1904 and is devoted to the manufacture of vertical boring and turning mills and universal saw tables. The buildings have walls of red brick with stone trimmings and the framework is of steel, making a practically fireproof construction. The main shop is 100 x 200 feet, three stories high in front to give room for the business and drafting offices. The engine and boiler house is complete in its equipment, power being furnished by a Nash three-cylinder gas engine, driving an electric generator from which current is distributed to the various parts of the plant and for operating the line shafting. Some of the machines are also direct-driven by motors. The heating plant, furnished by the Buffalo Forge Co. is also installed in this building. The blacksmith shop is immediately back of the engine and boiler house and the lavatories at the extreme rear. The plant is located on property 542 x 300 feet on a branch of the Lake Shore Railroad. The equipment consists of new tools throughout and the entire plant is complete in its appointments and arranged with a view to the convenience and comfort of the employees.

In the specifications which follow the general articles pertaining to forfeiture, delays, payments, insurance, repairs, etc., are omitted as are also the sections pertaining to lathing and plastering, and plumbing, metal work such as ceilings, gutters, etc., painting, and glass and glazing. The specifications so far as published, however, are complete in all their items.

### PARTIAL SPECIFICATIONS: LEHMAN & SCHMITT, ARCHITECTS.

#### Foundations.

EXCAVATIONS.—All excavations will be done by the Owner.

FOOTINGS.—The foundation walls and piers are to have stone footings of large flat stone 8 inches thick, laid in level courses in full beds of cement mortar, with the joints thoroughly grouted with same mortar.

The piers of columns are to be built of full size stones with bolt holes cut through the same.

The bearing stone for column bases to be smooth tool chiseled to a true and level surface.

PERCH STONE WORK.—All foundation walls and piers to grade line are to be built of large perch stone laid in random courses with square joints with one-fourth of all stone the full thickness of wall, the balance of walls to be laid up with two stones, all properly bonded

BACKING.—Fill in and back up solid all stone or other exterior work point up close to all copings and caps and render customary assistance to other mechanics as required in general building construction.

COVERING.—Provide materials and labor to properly cover the walls

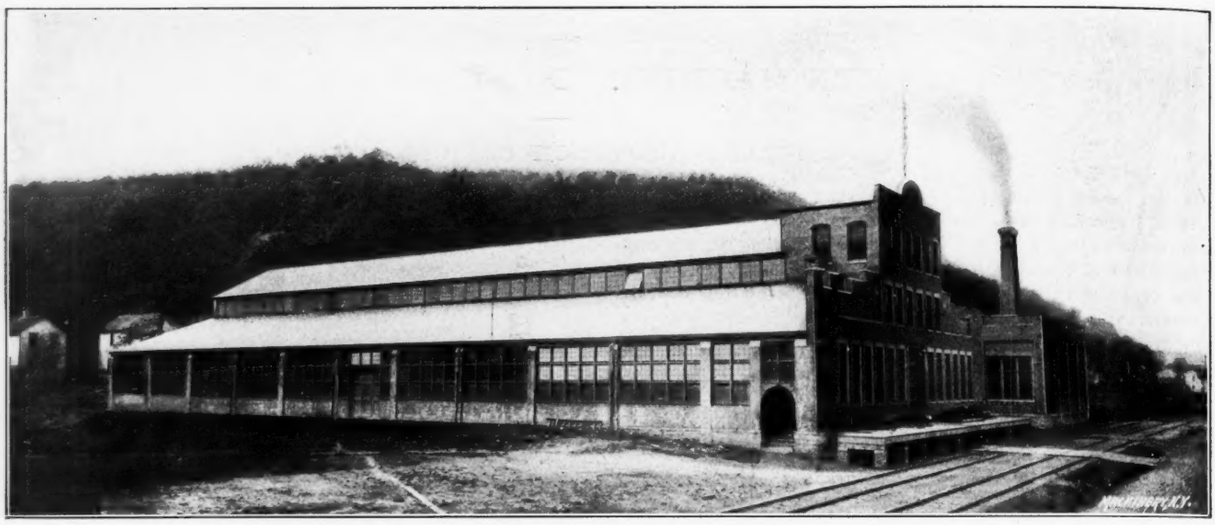


Fig. 2. General View, Colburn Machine Shop. Power Plant at Right.

together and laid with full beds and joints of cement mortar; all joints filled flush. The face of all walls to be rough hammer dressed and built to lines. The exposed walls on side and return to be rock-faced work with tooled margins.

MORTAR.—The mortar for all foundation work to be of cement and sharp screened bank and river sand, thoroughly dry, mixed to an even

from the weather, at all times and on final completion; repoint and clean all exposed brick work on fronts.

CENTERS.—The carpenter must furnish centers for each arch, templates for curved walls, also all blocks, strips or other woodwork required to be built into the walls during construction, and set all frames with proper braces.

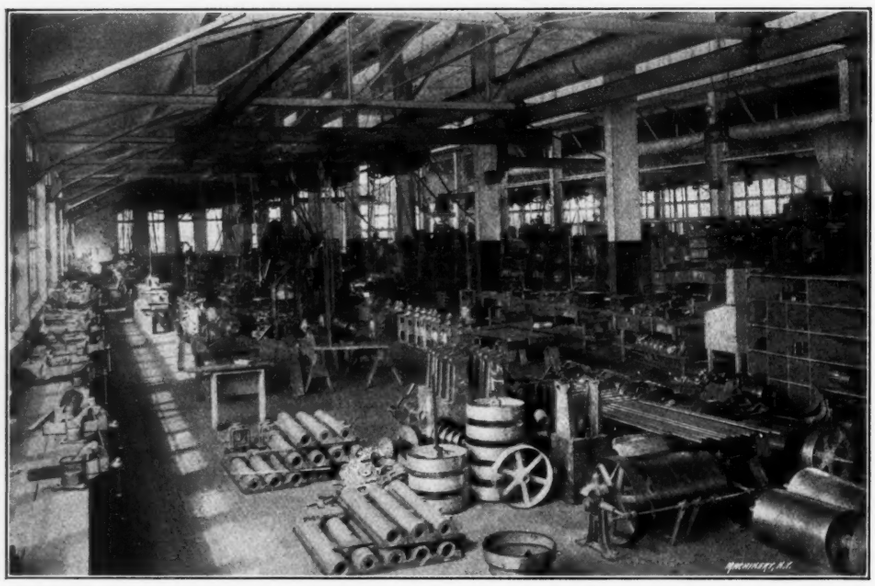


Fig. 3. Interior View in one of the Side Wings.

color before applying water and freshly mixed in such quantities as required for immediate use.

The filling of wall and bolt holes to be grouted with water and mortar so as to thoroughly fill all beds and joints.

The mortar shall be proportioned one part Empire Portland cement and three parts sand as before specified.

## Mason Work.

The buildings to be constructed under these specifications consist of a machine shop, engine and boiler house, blacksmith shop, lavatory and wash house, and are to be located upon the premises approximately as designed by block plan.

The owners are to do all the excavating required and are to build all foundations, walls and piers for the various buildings to the grade line designated by the drawings.

All walls, piers, pilasters, smokestack and other work shown or indicated on drawings as brick work shall be built of well hard-burned brick of even color, regular shape and size, laid with full beds and joints of good rich mortar, with struck joints on all exposed interior and exterior surfaces.

All openings, unless otherwise shown, shall have brick releaving arches not less than 8 inches deep, no joints to exceed ½ inch in thickness. All brick work to be laid in regular bonds and level courses to lines stretched on both sides of the wall; every sixth course in all walls to be headers.

The filling of walls to be rubbed to proper beds and joints, the walls in all cases to be built level to the exact height of bottom of all floor beams and trusses, and after same are laid shall be built up level to the top of same.

MORTAR.—The mortar for all brick walls, pilasters, smokestack, etc., shall be of rich lime and sharp screened river or bank sand.

ARCHES.—Build all face arches, pilasters, reveals, brackets, etc., as shown.

FRAMES.—The mason shall assist in the setting of all frames and other work and will not be allowed to build arches or circular walls without the proper center or template; he will also be responsible to keep all work plumb, level and undamaged after the same is set in place.

FACE BRICK.—The exterior facing of all brick walls to be laid up with selected common brick, with red putty mortar with neatly troweled struck joints. The inside facing of all walls to be laid with white mortar, struck joints.

The pilasters on side walls to be built up solid around steel columns and finished with a stone cap.

The exposed surfaces of all brick walls at main entrance to be laid up with selected brick and red putty mortar, the same as exterior.

CUT STONE WORK.—The large shop windows on first story, side elevations, will have wood sills, all other windows in first, second and third floors are to have stone window sill, droved work and all sill except for windows in finished offices shall extend through the wall; all shall be cut with proper washers, lugs and drips.

The coping and sill courses on all exterior walls to be of 2½-inch thick sawed flagging with faces droved work.

The sill courses, second story front, to match window sills; the caps of windows on front to be droved work.

The steps and platforms to main entrance to be of hard sand stone, rubbed finished, set on brick walls and joints pointed with cement. The ashlar at each side of these steps to be droved work.

The exposed walls on side and the return 2 feet on the machine shop building and the front and return of engine

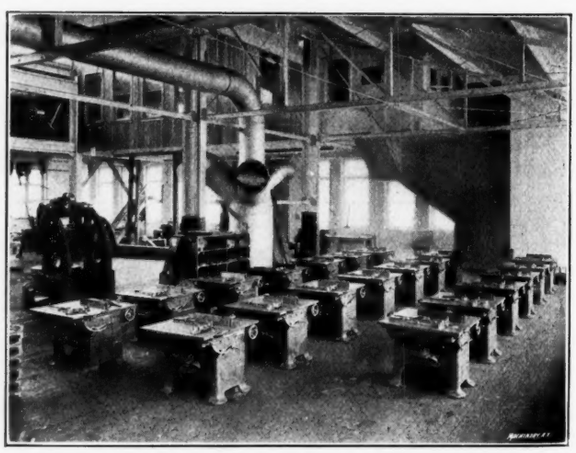


Fig. 4. View looking toward Offices, showing Colburn Saw Benches.

and boiler house building and the water table of all the buildings are to be rock faced work with tooled margins and wash.

The door sills to be same as water table course, but shall be cut with proper wash and lug, and shall extend over the full thickness of wall.

The piers under railway docks platform shall have 6-inch thick stone caps, the full size of piers.

The window and door sills of engine and boiler house, blacksmith shop, lavatory and wash house to be as above specified; all the window and door sills for these buildings shall extend through the wall.

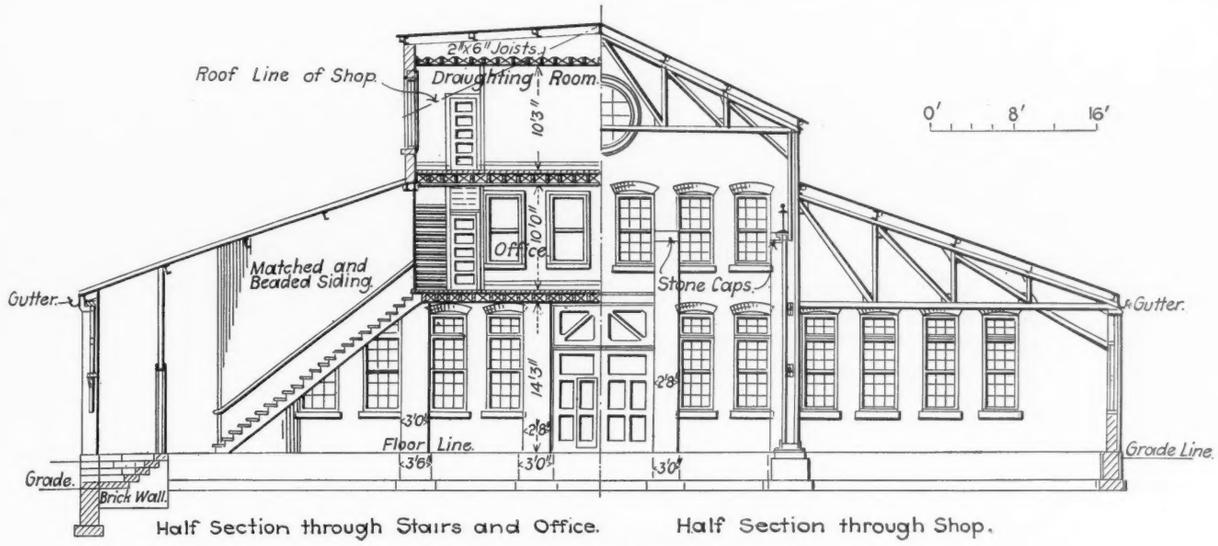



Fig. 5. Sectional Elevation through Machine Shop.

DAMP COURSE.—Cover all outside walls at grade line with double course of two-ply tar roofing felt. This damp course to be the full thickness of wall.

FLOORING.—The machine shop building and the blacksmith shop will be leveled to a surface 24 inches below the finished floor line by the owner. This space shall be filled up with clean cinders properly tamped, packed and rolled with a horse roller to a solid bearing 18 inches in thickness. The carpenter will lay wood sleepers, and the spaces between the same shall be filled up flush with crushed cinders well tamped. The cinders for all this work to be furnished on the premises by the owner, but shall be brought into the building, and all labor connected with spreading, packing and rolling the same to be done by the mason contractor.

The floor of engine and boiler house and of lavatory and wash house are to be of concrete 5 inches thick, which shall be graded in all directions, so as to drain to the outlets indicated on drawings.

These floors to be laid in two parts, the lower part 3½ inches thick and the upper part 1½ inch thick, the lower 3½ inches to be composed of one part Empire Portland cement, three parts river sand and five parts 1-inch broken stone, all thoroughly mixed and worked before water is applied and after water is put on to be again thoroughly worked and laid down and properly tamped in place. The top finishing coat of 1½ inch thick to be composed of one part Portland cement and three parts river sand, thoroughly mixed and worked and laid down into a uniform even thickness and finished with a wood float.

The whole floor to be graded and pitched to an exact pitch as directed. Each contractor shall submit with his bid a price per square foot for each concrete floor, to be added or deducted in case alterations are made.

REMOVAL OF RUBBISH.—After completion of all this work the mason contractor shall remove all rubbish from the premises and leave the lot clean for grading, which grading shall be done by the owner.

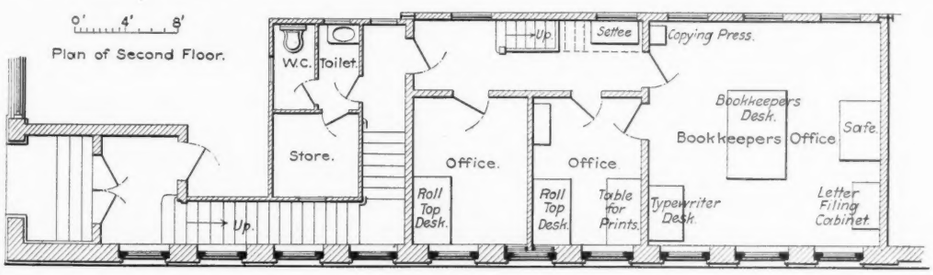



Fig. 6. Office Floor.

## Steel and Iron Work.

TESTS AND INSPECTION.—The contractor for this work shall afford the architects, superintendent or inspector all reasonable facilities for performing their work of testing and inspecting the materials and workmanship at the mills, shop and building; he shall also furnish, without extra cost, all test pieces required for said purposes, and shall pay the inspector for such tests and inspections a sum not exceeding $1.00 per ton of inspected material, which amount shall be paid upon the architects' order.

The contractor shall furnish the architect with copies of all iron detail drawings, which must be approved by the architects and inspector before the work is done. The responsibility for error in drawings to remain with the contractor.

To insure the acceptance of materials and workmanship, the test pieces must be of a quality conforming in every respect to the standard specifications, governing the physical properties of structural and special open hearth plate or rivet steel as adopted by The Association of American Steel Manufacturers, of August 9, 1895, which specifications are to form a valid part hereof as though fully written herein. All work delivered at the building must bear the inspector's mark of approval. No material shall be shipped from mill or shop until after inspector's approval. The acceptance of material or workmanship at the mill or shop will not be considered final, but the right is reserved to reject any material or workmanship, which, upon delivery at the building, shall prove defective at any time before the completion of contract.

PAINTING.—All surfaces that are inaccessible after being riveted, or that are inaccessible after erection, shall have two coats of pure red lead and linseed oil paint before riveted or erected. All work shall, after erection, be thoroughly cleaned with wire brushes and painted one coat of pure red lead and boiled linseed oil. No painting will be allowed in wet or freezing weather; all turned or planed surfaces shall be painted with a mixture of white lead and tallow before being exposed to the weather.

SCHEDULE.—The work herein included consists in furnishing, erecting and setting in position, in full accord with the drawings and specifications, all the structural steel and iron work shown on the drawings and all work indicated on drawings as iron or steel, either directly or by comparison with general drawings, details or specifications, all of which, unless specially mentioned to the contrary, shall be included in this contract.

The general schedule of the work will consist of columns, girders, beams, channels, trusses, lintels, and such plates, angle connections, and other work, as required to complete the various parts of the work.

COLUMNS.—The columns in side walls will be made of I beams with plate and angle bases and caps, riveted to same. The center columns will be made of plate and angles with base, cap and connections all riveted together. Each column to have such connections as required for bases, trusses, bracing and girders.

The base of each column to be anchored to the foundation with two bolts built into the mason work; these rods, with suitable templates, to be furnished by the owner and built in by the mason.

The columns in wash and locker room are to be round hollow cast iron with base and cap plates, all in one piece, both bearings turned to a true surface and the columns to be straight, true, and smooth castings.

BEAMS AND CHANNELS.—The beams for support of crane tracks, the rail for cranes, the channels for all roof purlins, the girders for support of side walls of third story offices, the lintels over door and window openings, the beams for support of rear wall of office building, and all other beams, girders and channels as shown on drawings are all to be of the sizes and dimensions shown on the various drawings, substantially framed and riveted together with standard connections, angles and plates. All roof purlins to be punched every 4 feet for ½-inch bolt for securing wood nailing strips. All other iron work supporting or securing wood work shall have holes punched directly into same as may be required for securing wood work in place.

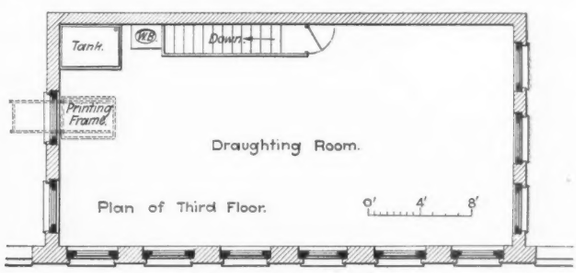



Fig. 7. Drafting Room.

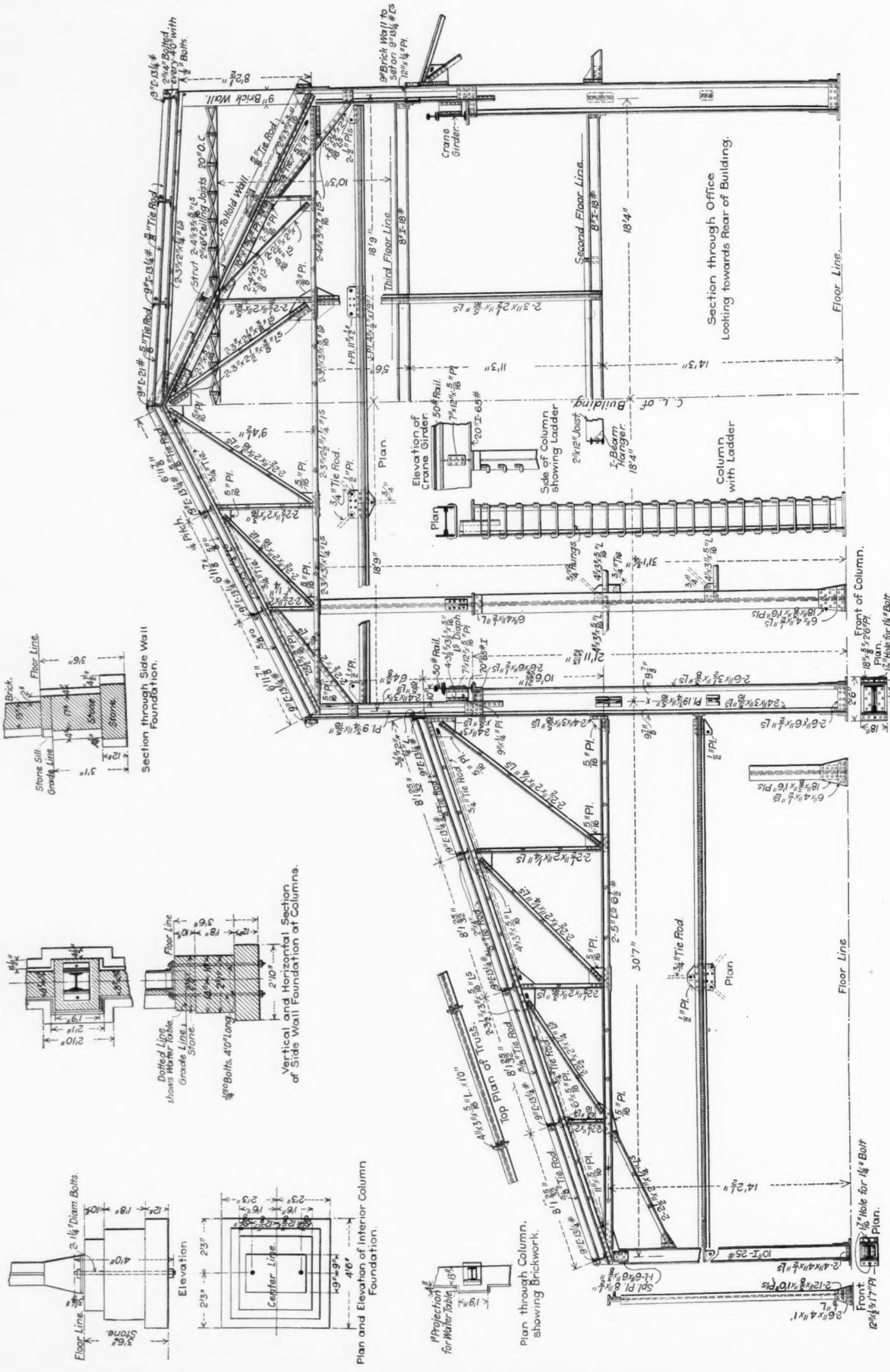



Fig. 8. Details of Steel Work and Foundations.

The bolts required for all such work to be furnished and secured by the carpenter.

TRUSSES.—The trusses for support of roofs are to be constructed of angle irons and plates, framed as shown by details, and all securely riveted together and to columns.

The main roof truss supporting rear wall of office to be reinforced with plates and heavy angles, suspension rods and beams as shown on drawings. All roof purlins to be riveted to trusses. All braces, struts, plates, ties, rods or other work shown shall be included.

LINTELS.—All lintels formed of two beams are to have cast iron separators and bolts and shall be set on standard size wall plate.

RODS.—The columns and trusses are to be braced with temporary and permanent iron rods which shall be arranged in three panels and shall include the bracing of columns and upper and lower chords of trusses in panels as shown on drawings.

DOORS.—The openings to boiler room for receiving coal are to have frames made of angle irons and plates, enclosing the entire opening the full width of walls, and shall have iron doors hinged to same and trimmed with suitable bars and fastenings to secure the same in place both open and closed.

All plates for this work to be 3-16-inch thick and all substantially riveted together.

The door at base of smokestack to have an angle iron frame and door properly hinged and trimmed in similar manner.

SIZES AND DIMENSIONS.—The size and weight of all material to be as shown by drawings and details; all material which is not figured shall be of such size and weight as required to complete the whole in accordance with the general drawings.

All rivets, bolts, plates, angles or other materials or work not especially mentioned to be furnished and included by this contractor so as to complete the entire framing in full accord with the general drawings, the whole of which to be erected, plumb, straight and true at all points and substantially riveted together.

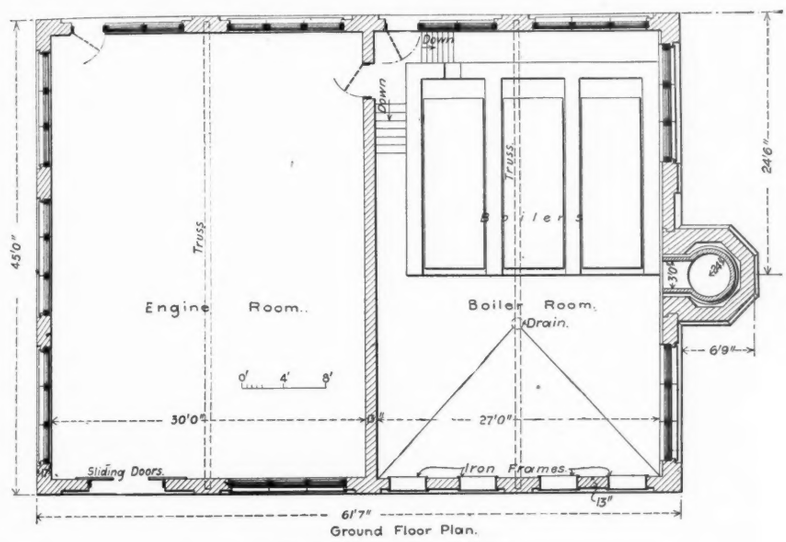



**Fig. 9. Plan of Power House.**

## Carpenter Work.

LUMBER.—All framing lumber such as joists, rafters, studding and beams, unless otherwise specified, shall be of thoroughly seasoned pine lumber of such sizes, shapes and dimensions as required by the drawings.

All finishing lumber and all finished wood work to be of the quality and kind hereafter specified, kiln dried, moulded and worked as shown by drawings.

CENTERS.—This contractor to furnish a center for each arch, template for all curved or octagonal walls, all blocks, strips and other wood work required to be built into the walls during construction, also all plates, boards or other rough lumber required for other mechanics' work.

CUTTING AND FITTING.—All framing, cutting and trimming wood work required for gas, water, steam, plumbing or other pipes, also all cutting and fitting of wood work as required to enable other mechanics to set their work in place, shall be done in such quantities and at such times as required to complete the various works on the building as shown by drawings or as may be required in order to fully complete the various parts as hereafter specified.

FRAMES.—All door and window frames shall be properly set and secured with braces and all sills and pulley stiles covered and protected during construction.

LINTELS.—All openings in brick or stone walls shall have suitable lintels of such size and radius as required for the various openings.

CLEANING.—This contractor shall, at all times, keep the building free and clean of rubbish, sweep out the entire building before painter's work is commenced, and as often as required remove the rubbish from the building and premises, and on completion remove all rubbish from the premises.

FRAMING.—All headers and trimmers in all joists and rafters are to be framed together with duplex joist hangers of the size corresponding to sizes of timber.

The holes for all hangers to be bored 1-16-inch larger than size of hangers and the ends of all joists neatly fitted to hangers.

SIZING.—All lumber to be sized to an equal width.

FURRING.—All outside walls that are to be plastered shall be furred with 1 x 2 inch strips set vertically 16 inches to centers, securely nailed to plugs driven into joints of brick work every 2 feet in height. All floors, walls and partitions shall be furred as required for enclosing pipes of various kinds.

JOISTS.—The joists for office floors 2 x 12 inches, ceiling joists 2 x 6 inches, set 16 inches to centers. These joists shall be built into front wall with duplex wall hangers. The shop end of same to be framed into I beams with duplex I beam hangers bolted to I beam. The ceiling joists to be framed and secured to angle iron and walls.

The floors of machine shop shall have 4 x 4 inch wood sleepers laid 24 inches to centers on a cinder bed, and filled between same with cinders as specified on page 9.

These sleepers to be blocked and leveled up by the carpenter and the cinders packed around same by the mason.

The platform to have 8 x 12 inch beams, 6 x 12 inch joists and 2 inch plank flooring.

PURLINS.—The purlins on machine shop roof will be of channels and each shall have 3 x 4 inch surfaced wood strips bolted to channel every 4 feet with ½-inch bolts. The roof trusses for blacksmith shop, engine and boiler house are to have similar wood strips bolted to tops of same.

Similar strips shall be secured to all other iron framing to which wood work must be connected, the holes for all such bolts to be provided by the contractor for iron work, but all bolts for securing the wood work to be furnished by the carpenter.

RAFTERS.—The rafters for engine and boiler house and blacksmith shop to be 2 x 10 inch rafters, for lavatory and wash house 2 x 8 inches, all set 16 inches to centers. The ends built into walls and secured to nailing strips of trusses. The rafters of wash house roof to be supported on an 8 x 12 inch wood beam set on iron columns.

ROOF BOARDS.—The roof boards for machine shop to be 1¾-inch thick pine matched and surfaced both sides and secured to strips bolted to purlins.

All joints on roof boards to be made on nailing strips and cut at an angle of 30 degrees across the board. The roof boards for other buildings are to be of ⅞-inch common matched pine boards. All roof boards to be securely nailed to all bearings.

VENTILATOR.—The ventilator over blacksmith shop to be framed with 2 x 4 inch studs and 2 x 6 inch rafters, the exterior and interior sheathed with roof boards.

PARTITIONS.—All interior partitions on front stairway and offices to be framed with 2 x 4 inch studs with double plates and sills and double studs at all openings all thoroughly spiked together.

FLOORING.—The machine shop to have a 1¾ x 6 inch surfaced four sides pine floor, laid with close joints and securely nailed to sleepers. The floor in blacksmith shop to be finished with cinders; the floor in the engine house and wash to be of concrete.

The office floors on second and third floors to have a rough flooring of ⅞ x 6 inch matched common pine flooring, laid diagonally across joists.

The finished flooring in these rooms to be ⅞ x 3 inch matched quarter sawed Georgia pine, with all rough and uneven spots smoothed after laid and the whole floor left clean and smooth for painter's finish, all matched floor to be blind nailed every 16 inches.

WINDOWS.—All windows on front and rear elevations and the windows in offices of the machine shop, all windows in blacksmith shop, and the windows in engine and boiler house shown on drawings, with two or three sash each, are to have box frames made with 1⅛-inch pulley stiles, ⅞-inch boxing, 1¾-inch sills and heads, 1¾-inch blind stops and ½-inch thick moulded sash stops and a bead finished on interior. The sash to be 1⅜-inch thick, all double sash double hung with cast iron weights, bronzed iron axle pulleys and braided sash cord, trimmed with bronze iron sash locks, lifts and pulls.

The transom sash in all triple sash windows to be stationary.

The circular windows in boiler house and in end gable of machine shop to have 1¾-inch thick frames made of strips sawed to proper radius with 1⅜-inch sash, all sash to be stationary.

The single sash windows in lavatory and wash house are to have 1¾-inch rabbeted plank frames with 1⅜-inch sash hinged at bottom and trimmed with chain and spring catch.

The windows in side wall of machine shop are to be plank frames with 1⅜-inch sash, the lower sash to be pivoted and trimmed with proper fastenings, the center and upper sash to be fixed.

The windows in lantern of machine shop to have plank frames with 1⅜-inch sash, every fourth sash to be pivoted and secured with proper fastenings, the balance to be fixed.

The windows in lantern of blacksmith shop to be made in similar manner.

All interior or other frames not especially mentioned to be made to correspond with those specified.

The glass for all two light windows to be best double American glass; all other glass to be best double American glass; all to be bedded, bradded and back puttied and left whole and clean on completion of building.

All window frames and sash to be made of white pine lumber. The exposed parts of all frames to be made of selected material with not exceeding one ½-inch knot in any one piece.

The lumber for all sash to be clear, all to be made according to detail drawings, properly set and secured in place and left in perfect working order.

DOORS AND FRAMES.—The frames for all doors in brick walls to be 1¾ inch thick, rabbeted as required. The frames for all doors in stud partitions to be ⅞-inch thick, with ½ x 2 inch moulded stop nailed on. The main entrance door to machine shop offices to have moulded frame and the entrance way finished with a moulded wood arch with panels as shown.

The exterior double, sliding and swinging doors are to be made with 1⅜-inch frames, properly mortised and tongued together with 1⅛ x 2¼ inch face, round corner matched strips, blind nailed and secured with screws to the framing. These doors to machine shop to be divided and swung in parts as indicated. All other doors are to be 1¾ inch thick with five plain moulded horizontal panels

The doors in offices to have white pine rails and stiles and Georgia pine panels and shall be hand smoothed for oil and a varnish finish, all other doors to be of white pine, smoothly finished for painting.

Each interior door to be hung with three bronze plated loose pin steel butts and trimmed with mortise brass face lock with bronze knob, plate and trimmings.

The exterior single doors to be hung and trimmed in same manner.

The large double swinging doors to be hung with heavy wrought iron strap hinges bolted to wall and doors.

The sliding doors to be hung with approved iron top hangers and track secured with suitable sliding door locks.

Transoms on all exterior doors to be properly hinged and trimmed with transom lifts.

The exterior doors to coal room to be of iron, as before specified.

All hardware and trimmings to be of such patterns as may be selected by the architect.

## Roofing.

The roofs of the machine shop building, excepting the three story portion of the front, shall have a slate roof. The three story part of this building and the roofs of engine and boiler house, the blacksmith shop and the lavatory and wash house shall have gravel roofs, all to be put on in the manner hereinafter specified.

Where slate roofing is specified cover roof boards with one layer of slaters' roofing felt properly lapped (3 inches); on the felt shall be laid with a 3-inch triple lap best quality C green slate, 14 x 20 inches and each slate shall be nailed with two galvanized iron slating nails. When building is ready for occupancy slate roofer shall return and repair any damages to slate caused by carelessness or by other mechanics' work, and shall leave the same in good repair upon the final acceptance of building.

Where gravel roof is specified the roofs to be covered with four-ply felt and gravel roof. The three-ply layer of best tarred felt shall be laid in the ordinary manner, properly coated with hot pitch and secured with tin caps and nails. After the entire roof is covered with this three-ply felt a separate layer of one-ply Warren's best asphalt shall be covered with hot asphalt over the entire surface and then the entire roof covered with hot asphalt and fine gravel, properly smoothed off.

The side walls and all projections above roof are to be flashed and cap flashed with best McClure's charcoal iron Ic roofing tin as hereafter specified. The felt to be lapped and turned up on all side walls and projections over the tin.

SHEET METAL WORK.—All side walls and projections above roof are to be flashed with best Ic. roofing tin 12 inches wide, bent so as to lay 6 inches on the roof and 6 inches against the walls and properly secured in place.

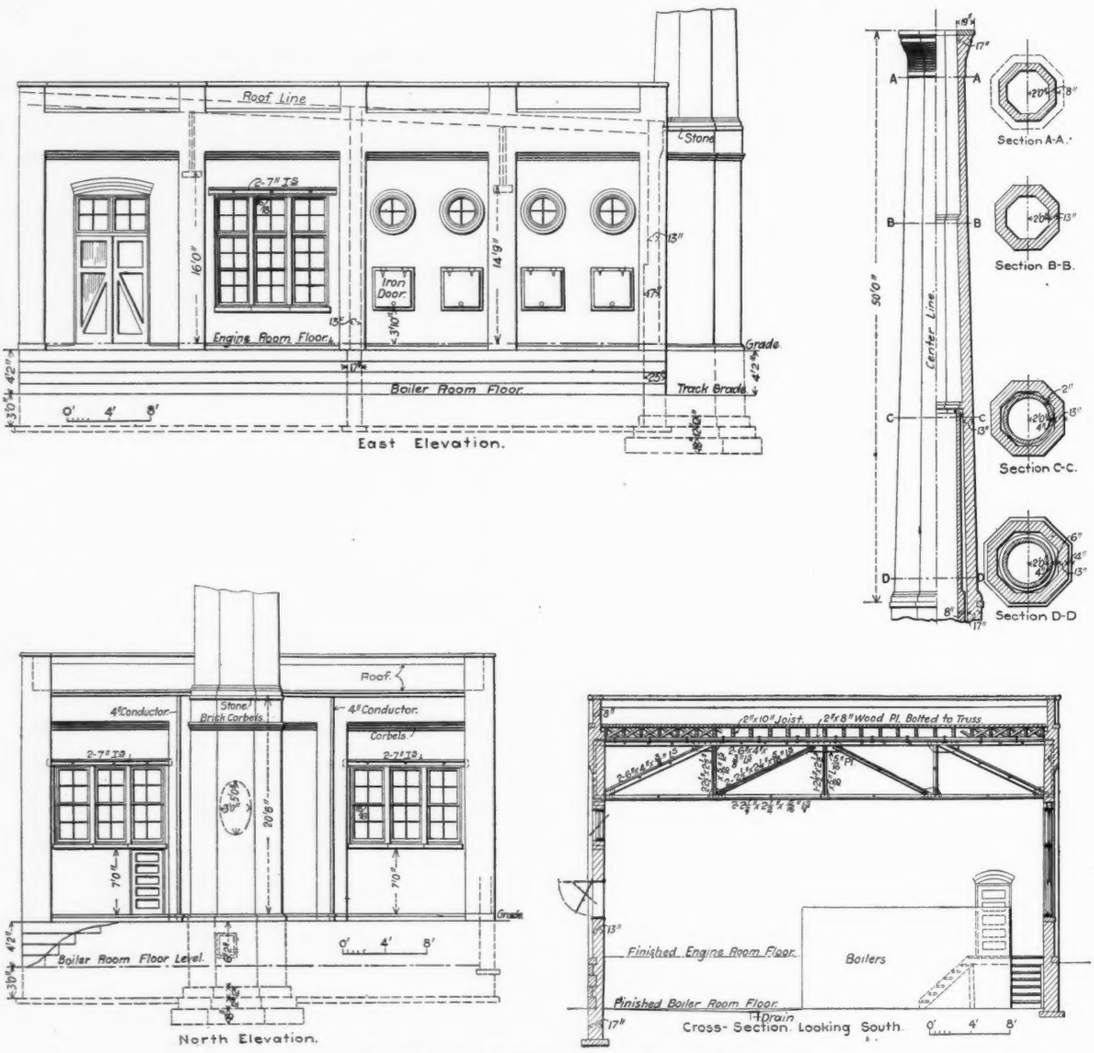



Fig. 10. Elevations and Sections of Power House and Chimney.

The roofing felt is to be laid over the same properly tarred and secured, and after this is applied cap all flashing with same tin, which shall extend to within 1 inch of roof. The upper edge to be turned into the joints of mason work properly plugged and joints cemented.

VENTILATOR SHAFTS.—The exterior of ventilator shafts, including jambs, bases and sills of all openings in same, are to be covered with same quality tin laid with flat lock and soldered joints and cleats properly nailed.

The windows in the ventilator of machine shop building will be flashed to roof with 12-inch No. 22 galvanized iron flashing. The ridge roll on the ventilator will be of 18-inch galvanized iron.

* * *

For centuries man's productive power might be compared to quantity $x$, with an exponent of 1. In somewhat plainer language a man's working effort under the primitive conditions which existed in early times was absorbed in producing the food and simple clothing required for himself and those immediately dependent upon him. He left little behind to show that he had ever lived at all, and his descendants inherited little to ameliorate their miserable condition. But the exponent of efficiency was not 1, but rather a very small fraction greater than 1, so that gradually the condition of the human race has bettered, but it has taken untold centuries to increase the knowledge of constructive arts to such a state as qualify people to be considered civilized. Representing the condition of absolute savagery by a straight line, the improvement in living may be considered as a curve, which for thousands of years has pursued a course closely paralleling the base line, but constantly tending upward. During the past 150 years this upward tendency of growth has been very marked indeed, especially from a mechanical standpoint. The effect of machinery, especially the development of motive powers, like the steam engine, means that man's dynamic power has enormously multiplied. His work effort is not now almost totally absorbed in mere pursuit of food and protection, but each generation produces much more than it consumes, hence, productive power is continually increasing.

* * *

A convenient rule for approximating the safe load (in pounds) for chains is to square the diameter of the link in fourths of an inch, and multiply the result by 1,000. For example, a ¾-inch chain should safely carry a load of $3^2 \times 1{,}000 = 9{,}000$ pounds. Another rule giving the load in English or long tons is to square the diameter of the link in eighths and divide by 10. For example a ¾-inch chain would show by this rule a safe working load of $\frac{6^2}{10} = 3.6$ long tons, or 8,064 pounds. A 1-inch chain figured by these rules shows a safe load of 16,000 and 6.4 long tons or 14,336 pounds, respectively.

## FORMULAS AND CONSTANTS FOR GAS ENGINE DESIGN.

SANFORD A. MOSS.

Definite rules will be given for the size of all of the more important parts of a gas-engine. The formulas are rational whenever possible, but in some cases are necessarily empirical. An attempt has been made to place everything on a more rational basis than usual. The constants and co-efficients given are for the most part taken from an investigation of current practice in gas engine design, made at Cornell University some years ago, and reported upon at the time.* An effort has been made to arrange everything in the most convenient form for a designer's use.

*General Remarks.*—The case to which the rules mainly apply is that of a single acting, trunk piston, stationary gas engine between 5 and 100 horse power. All pressures and stresses are in pounds per square inch, and all dimensions in inches. $d$ is the cylinder diameter, and $l$ the length of stroke, both in inches; $p$ is the maximum pressure during normal operation. This varies from 250 to 350, the usual value being 300 pounds per square inch. The stresses in the various parts which are most important are the continuously repeated stresses due to constant repetition of this normal pressure, and not the occasional higher stresses due to a high value of $p$ produced by excessive explosions now and then. Hence the normal value of $p$ rather than the occasional extreme value is the one to be used in the formulas.

*Thickness of Cylinder Walls, t.*—This depends upon the stress $s$ which can be safely allowed for continuous repetition. Considering the cylinder as an indefinitely long pipe with uniform fluid pressure, and adding a constant for reboring, crooked cores, etc., it may be shown that the thickness necessary for a stress $s$ is

$$t = \left(\frac{1}{2s}\right) p\, d + \frac{1}{4}$$

Owing to the stiffening effect of the jacket, unstressed portion of walls, and cylinder ends, a rather high value of the apparent stress may be used in this formula. A safe value is 2450. Then

$$t = 0.000204 pd + \tfrac{1}{4}$$

If $p$ has the usual value, 300, this reduces to

$$t = d/16 + \tfrac{1}{4}$$

*Thickness of Jacket Walls, T, and of Water Jacket, j.*—These are determined almost wholly by considerations of molding and casting, and depend directly on the thickness of the cylinder walls $t$. Safe values are

$$T = 0.6t \text{ and } j = 1\tfrac{1}{4}t$$

*Cylinder Head Studs; Number Used q, and Outside Diameter, o.*—Satisfactory results will be obtained by use of the empirical expression

$$q = 2/3d + 2$$

The nearest whole number must of course be used.

If the initial load on the studs, caused by screwing them up, is not greater than the load due to the explosion, the latter gives the maximum stress $s$ at the root of the threads of the studs. (The nuts of course may be carelessly screwed up tighter, causing unknown stresses.) It may be shown (since the area at the root of a thread is about 0.7 of the outside area) that the diameter necessary for a stress $s$ is

$$o = \frac{1}{\sqrt{0.7\,s}} \sqrt{\frac{p}{q}}\, d$$

A safe value for the stress is 7800. Then

$$o = 0.0135\, d \sqrt{\frac{p}{q}}$$

If $p$ has the usual value, 300, and $q$ is 8 or thereabouts this reduces to

$$o = d/12$$

*Length of Piston, L.*—Let $u$ be the ratio of the length of the connecting rod (distance between centers) to the radius of the crank. A usual value for this is about 5. Let $b$ be the average bearing pressure on the projected area of piston ($Ld$ square inches) during the explosion stroke. The piston must be long enough to give a safe value to $b$ in order to avoid undue wear. It can be shown that the average total load on the projected area of the piston (due to connecting rod thrust only) is $pd^2 \times 0.22\pi/4u$. Hence the length of piston necessary for a bearing pressure $b$ is

$$L = \left(\frac{\pi}{4}\,\frac{0.22}{b}\right) \frac{p\, d}{u}$$

A safe value for $b$ is 7 pounds per square inch. Then

$$L = 0.025 pd/u$$

If $p$ has the usual value 300 and $u$ the usual value 5 this reduces to

$$L = 1\tfrac{1}{2}d$$

The weight of reciprocating parts gives an additional pressure on the projected area of the piston, which is usually slight compared with the rod thrust. In cases where it becomes appreciable it should be taken account of, however, by adding the bearing pressure produced by weight to that produced by rod thrust, to obtain $b$.

*Thickness of Rear Wall of Piston, z.*—This depends upon the stress $s$ which can be safely allowed. By considering the wall as a circular plate, fixed at the circumference and without ribs it may be shown that the thickness necessary for a stress $s$ is

$$Z = \left(\frac{0.41}{\sqrt{s}}\right) \sqrt{p}\; d$$

Owing to the fact that ribs are usually added to help support the wall a high value of the apparent stress may be used in this formula. A safe value is 5320. Then

$$Z = 0.00562 \sqrt{p}\; d$$

If $p$ has the usual value, 300, this reduces to

$$Z = d/10$$

*Length and Diameter of Wrist-Pin (Piston Pin), l" and d".*—Let $s$ be the stress in the wrist-pin due to continuous repetition of the pressure $p$, and $b$ the bearing pressure on the projected area of the wrist-pin ($l''\,d''$ square inches) at the instant of maximum pressure, when the tendency to squeeze out the oil is greatest. The length and diameter of the wrist-pin must be such as to give $s$ and $b$ safe values. By taking the wrist-pin as a beam uniformly loaded, and supported at points $l''$ apart it may be shown that the diameter and length necessary for a stress $s$ and a bearing pressure $b$ are

$$d'' = \sqrt[4]{\frac{\pi}{4\,s\,b}}\; \sqrt{p}\; d \text{ and } l'' = \sqrt{\frac{\pi\, s}{4\, b}}\, d''$$

Safe values for $S$ and $b$ are 10,500 and 2,800, respectively. Then

$$d'' = 0.0128\; d \sqrt{p} \text{ and } l'' = 1\tfrac{3}{4}\, d''$$

If $p$ has the usual value 300 then reduce to

$$d'' = 0.22d \text{ and } l'' = 1\tfrac{3}{4} d''$$

*Area of Mid Section of Connecting Rod, a.*—Let $k$ be the factor of safety of the connecting rod or ratio of the breaking load to the actual maximum working load. Then the area must be such that $k$ has a safe value. Let $c$ be the distance from center to center of the rod, and $r$ the radius of gyration of the mid-section. If the mid-section is round, having a diameter $D$, $r^2$ is $D^2/16$. If the mid-section is rectangular, having a height $H$ then $r^2$ is $H^2/12$. It can be shown (by using Ritter's formula for long columns; end coefficient unity for ends free but guided; elastic limit of material, 35,000, modulus of elasticity, 29,000,000; neglecting obliquity and inertia of rod which nearly neutralize each other) that the area necessary to give a factor of safety $k$ is

$$a = \frac{k}{44\,560}\, p\, d^2 \left(1 + \frac{0.00012\, c^2}{r^2}\right)$$

A safe value for $k$ is 3.9. Then

$$a = 0.0000875\; p\; d^2 \left(1 + \frac{0\ 00012\ c^2}{r^2}\right)$$

If $p$ has the usual value 300 and if the mid-section of the rod

*Sibley Journal, June, 1903. *American Machinist*, 1904. Vol. 27, page 482.

is circular and of diameter $D$ and if the proportions are such that $1 + \frac{0.00012C^2}{r^2}$ has a value of about 1.6 as is usually the case, this reduces to

$$D = 0.23d$$

*Diameter of Crank Pin $d'''$.*—This depends upon the stress, $s$, which can be safely allowed. Let $l'''$ be the length of crank-pin journal, $l'$ the length of the main bearing journal and let $m$ be one-half of the distance from center to center of the main bearings. A center crank engine is assumed.

$M = m - (\frac{3}{8}\, l''' + \frac{1}{4}\, l')$ is a quantity needed in our formulas. (It is the arm of the effective bending moment on the crank-pin for the stress caused by the reaction on the main bearing due to the explosion. This bending moment is the only one which need be taken into account. It can be shown that all other effects, such as inertia, centrifugal force and obliquity of rod, effect of counter balances, weight of flywheels, belt-pull, etc., all practically neutralize each other.)

Then the usual relation between stress and bending moment gives as the diameter necessary for a stress $s$

$$d''' = \sqrt[3]{(4/s)\, M\, p\, d^2}$$

A safe value for $s$ is 10,600. Then

$$d''' = \sqrt[3]{0.000379\, M\, p\, d^2}$$

If $p$ has the usual value 300 and if the proportions are such that $M$ is about $0.6d$, as is usually the case, this reduces to

$$d''' = 0.41d$$

*Length of Crank Pin Journal $l'''$.*—Let $d'''$ be the diameter of the crank pin, and let $b$ be the average bearing pressure on the projected area of the crank pin ($d'''\, l'''$ square inches) due to average value of the load during a complete cycle. The length of the crank pin must be such that $b$ has a safe value, in order to avoid heating. It can be shown that the average value of the total load on the crank pin taken regardless of directions is about 14½ per cent of the maximum load due to the explosion. Hence the length of crank pin necessary for a bearing pressure $b$ is

$$l''' = \left(\frac{0.145\,\pi}{4\,b}\right)\frac{p\,d^2}{d'''}$$

A safe value for $b$ is 213. Then

$$l''' = 0.000535 p d^2/d'''$$

If $p$ has the average value 300 and if $d'''$ is $0.41d$ as shown above to be necessary in an average case this reduces to

$$l''' = 0.95d'''$$

*Dimensions of Crank Throws.*—Let $x$ be the thickness (in the direction of the shaft axis) of the throws of a center crank engine, $y$ the breadth (perpendicular to the shaft axis) and $d'''$ the diameter of the crank pin. Then safe values are

$$x = \tfrac{5}{8}d''' \text{ and } y = 2\tfrac{1}{8}x$$

*Diameter of Crank-Shaft at Main Bearings, $d'$.*—This depends on the stress $s$ at the inner edges of the main bearing journals, which can be safely allowed. Let $l'$ be the length of the main bearing journal. A center crank engine is assumed.

$M' = 0.325l' + 0.090l$ is a quantity needed in our formulas. (It is the arm of the effective bending moment on the crank shaft at inner edge of main bearing, for the stress caused by the reaction on the main bearing due to the explosion. It can be shown that this gives a moment equal to the combined bending and twisting moment, taking flywheel weight, belt pull, etc., into account.) Then the usual relation between stress and bending moment gives as the diameter necessary for a stress $s$

$$d' = \sqrt[3]{(4/s)\, p\, d^2\, M'}$$

A safe value for $s$ is 9,500. Then

$$d' = \sqrt[3]{0.000422\, p\, d^2\, M'}$$

If $p$ has the usual value 300, and if the proportions are such that $M'$ is about $0.4d$, as is usually the case, this reduces to $d' = \frac{3}{8}d$.

*Length of Main Bearing Journals, $l'$.*—A single cylinder with two main bearings is assumed. Let $d'$ be the diameter of the crank-shaft at the main bearing, and let $b$ be the average bearing pressure on the projected area of a main bearing ($d'l'$ square inches) due to the average value of the load during a complete cycle. The length of main bearing must be such that $b$ has a safe value, in order to avoid heating. It can be shown that the average value of the total load on the main bearings, taken regardless of directions, and taking account of belt pull, flywheel weight, etc., is about 1/3 of the maximum load due to the explosion. Hence the length of each main bearing necessary for a bearing pressure $b$, is

$$l' = \left(\frac{\pi}{24\,b}\right)\frac{p\,d^2}{d'}$$

A safe value for $b$ is 123. Then

$$l = 0.001068 p d^2/d'$$

If $p$ has the average value, 300, and if $d'$ is $\frac{3}{8}d$, as shown above to be necessary in an average case, this reduces to

$$l' = 2\tfrac{1}{4}d'$$

*Outside Diameter of Fly Wheel, $D$.*—The stress in the rim of a cast iron fly wheel of the usual type depends only on the velocity of the rim, $V$, in feet per minute. Hence the fly wheel diameter should be such as to give $V$ a safe value. If $N$ is the R.P.M., the diameter necessary to give a velocity $V$, is

$$D = \left(\frac{12\,V}{\pi}\right)\frac{1}{N}$$

A safe value for $V$ is 3,220 feet per minute. Then

$$D = 12{,}300/N$$

*Weight of Fly Wheels, $W$.*—Let $W$ be the total weight of all fly wheels, in pounds, for the case of a single cylinder, hit and miss engine. Let $f$ be the speed fluctuation coefficient. This is the ratio of the difference between the maximum and minimum R.P.M. to the average R.P.M., $N$. The flywheels must be such as to give a safe value to $f$. Let $H$ be the rated brake horse power, and $D$ the outside diameter of the wheels. The greatest fluctuation is at light loads, and the least working load is taken as when the engine misses three times between each fire. Then it can be shown (on the basis that maximum indicated horse power is 1.4 times rated brake horse power, $H$, that the radius of gyration of an average fly wheel is 0.83 of the outside radius; and that the ratio of the energy added to the wheel and causing the maximum acceleration in the case considered, to the net indicated energy developed per cycle if exploding every time, is 1.197) that the fly wheel weight required to give a fluctuation coefficient $f$ is

$$W = \frac{272{,}300{,}000{,}000}{f}\,\frac{H}{D^2N^3}$$

A safe value for $f$ for ordinary engines is 0.054 (5.4 per cent). Then

$$W = 5{,}000{,}000{,}000{,}000\,\frac{H}{D^2N^3}$$

If we have the average value of the rim velocity above found so that $D$ is about $12{,}300/N$, this reduces to

$$W = 33{,}000H/N.$$

* * *

One drawback to the extensive use of high-speed steel for drilling is the cost of twist drills and the increased liability to breakage when used for rapid production. In commenting on this fact the editor of the *Railway Engineer* says that one of the causes of the failure of high-speed drills in Great Britain is that the men cannot be depended upon to slack off the feed when the material at the bottom of the hole is getting thin. The result is that the heavy pressure necessary to force the point of the drill into the work pushes the drill through the thin bottom and often breaks it. Unconsciously this comment is an arraignment of modern drilling machines as it is practically a statement that the spring of tools is excessive when working. If the drilling machine is stiff enough to carry the drill with the required feed without excessive springing the breaking through of the point of the drill when nearing the bottom of the hole should not cause it to "hog in" excessively and cause breakage. It is only when the design is weak that such troubles as this occur.

* * *

The best grade of anthracite coal measures about 32 cubic feet per ton of 2,000 pounds. Poor grades require more space, but if an excess of stone is carried less than 32 cubic feet may weigh a ton.

## ESTIMATING TIME ON MACHINE WORK.

J. H. VAN YORX, JR.

To cover the ground which the editor in the October number of MACHINERY evidently desires, in calling for data upon estimating, would take a long series of articles, if not a volume, to include the different phases of methods. It would appear that widely distributed short articles would suit the purpose to better advantage. This article is written with that idea. What few points are here covered may be an aid to some and to these same points others will take exception.

At best "estimating" is a polite and dignified term for guessing, and a man may be a good guesser or a bad. One who may be considered an accurate estimator in one environment would be a bad guesser if placed in another. The man who lays down a rule and rigidly follows it will surely come to grief sooner or later. There are, however, certain general rules to be followed in a general way. For instance, we know that a certain machine which travels (or the piece travels, as the case may be,) at a certain speed and with a certain feed will accomplish a certain amount of work in a given time; but here is where our knowledge ends and our guessing begins. This knowledge is often only a small proportion of the work to be performed. A certain gentleman who considered himself and was generally considered to be an accurate estimator, always allowed one minute to put a piece into a machine and one minute to take it out, no matter what the piece was when in some cases it would take ten minutes at least. He would allow too much time, according to a set rule, in another direction, and when the mistakes were averaged up they generally came something under actual time. This was laid to unnecessary losses, and he was considered a "close estimator." He was fortunate in having his set rules counterbalance each other. We all have our weaknesses of judgment and the "pot cannot call the kettle black" with consistency. Therefore we guess, in spite of the fact that a stop watch can be held to get accurate time for putting pieces of work into the machine, setting cuts, grinding tools, etc. The time thus obtained is accurate knowledge for that piece and that machine at that particular time, but it will be useful again only in estimating upon that same class of work. If this statement does not bring out strong protests from pens, it will from minds of a number who think they know because ninety out of every hundred of their estimates prove to be good guesses. The best that estimating can do, in the writer's opinion, is to establish limits based upon good judgment, either side of which it would be dangerous to go.

The machine shop is full of surprises and unusual conditions, no matter how familiar we become with it, and if they are not agreeable ones, some one must pay for them. It may be a good excuse for the estimator that certain unlooked-for conditions are unusual and cannot be considered. An uncontrollable condition unexpectedly arising may "let him out," as far as his work is concerned, but it does not pay for the loss. On the other hand, an estimator cannot add four or five hundred per cent to cover this, for he would drive all trade away with his high prices. The estimator, then, is a prophet, and a prophet is one who guesses at what is about to happen. To illustrate: a few days ago a simple job was given to a man on piece work, upon which there was an estimate of ten minutes for each piece. The piece was an ordinary nut 1½-inch hole, twelve-thread standard, to be chucked, tapped, faced and counter-bored. Actual time taken for the work was something under twelve minutes each, yet this man turned in his contract card, losing double the worth of the job. The facts of the case were that thirty-eight pieces had been made before eight good ones were obtained. The trouble was with the thread; the stock was changed, and the trouble grew worse rather than better; the tap was experimented with in every conceivable way, and finally a third lot of stock was tried and the job was finished in good shape. That, of course, was not "up to" the estimator, but the shop had to pay for it just the same. That is one thing; here is another. A piece was to be bored on a horizontal boring machine; the piece was simple in appearance with a bearing in which a rack was to operate. At two different points in this bearing were openings for rack pinions which operated the rack. The actual machine work amounted to but little, the measurements were most difficult to get, they had to be accurate, and there was no point from the outside from which to measure. It had to be done through a small opening through which the hand was to be passed. Here a new difficulty arose. The workman's hand was too large to pass through the opening and as the foreman's hand was smaller he had to do the measuring. Altogether, the time estimate was knocked into a "cocked hat." This estimate was the composite of several others. There is no rule to cover these occurrences, particularly in a shop where a variety of work is done. In this case a jig would have been out of the question as the job was "special" and would in all probability never be done again. A person who takes known figures and facts ceases to be an estimator and enters another class.

The foregoing is merely to show that what follows may be true in general of the conditions by which the writer is surrounded (a machine shop, manufacturing boring mills and lathes), yet would perhaps be totally in error for another, who might well say that this article is wholly incorrect. The writer might return the compliment for any that he might write.

One hard and fast rule that is always well to follow is: When in doubt be liberal.

The ever-increasing scope of turret machine work, causing a continual change of conditions, adds to the difficulties of accurate estimating. The number of pieces to be done, the kind of tools to be used, the location of the place where they are kept when not in use, whether the workman gets his own

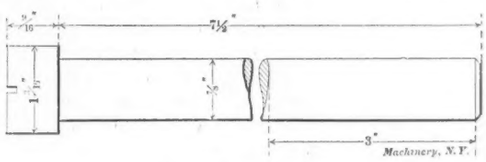



Fig. 1. A Sample Screw.

stock or has it brought to him, whether it is in a rack near his machine (if he is to use bar stock) or if it is outside around the corner, two blocks away. We can figure the time to make a screw like the one in the accompanying sketch (Fig. 1) in a number of different ways.

FOR ONE PIECE.

| | Min. |
|---|---|
| To set up machine | 30 |
| To size and start | 1 |
| To cut to shoulder | 4 |
| To cut thread | 2 |
| To cut off | 1 |
| To get sizes | 1 |
| Extras | 2 |
| | 41 |

FOR THIRTY PIECES.

| | Min. |
|---|---|
| To set up machine (average) | 1 |
| To size and start | 1 |
| To cut to shoulder | 4 |
| To thread | 2 |
| To cut off | 1 |
| To get sizes and grind tools | 1 |
| Extras | 2 |
| | 12 |

The above estimate for semi-automatic turret lathes.

If the workman gets his own stock from five to fifteen minutes would have to be added according to circumstances; this would leave the screw ready to be slotted and polished. Now to analyze the figures.

For screw machine work of this class it has been found by actual timing that an average of one-half hour to get the tools properly set and stock in the machine ready to start the work is a liberal allowance. This figure is used more or less arbitrarily unless there are known conditions which would change it. To "size" the stock and use the starting tool takes approximately one minute. The diameter of the stock used in this class was 1 1-16 inch, making about 160 feet of metal to turn off at 1-80-inch feed. This, at 40 feet per minute, would be four minutes. It can be seen right here that a difference would arise if conditions should force a limit of 30 feet or

allow 70 feet, or if the stock were poor 1-100-inch feed might have to be used. From tables we find that a piece ⅞ inch in diameter, threaded 3 inches, will take a fraction over one minute; this would be called two minutes. Again tables show cutting off 1 1/16-inch stock to take approximately one minute. No time would be allowed to sharpen and keep the tools in shape for one piece, for they should be in good condition both when a workman receives them and when he has finished with them. One piece ought not to materially affect their condition. A more liberal allowance should be made for getting sizes (according to the number of sizes to be gotten) on one piece than on a number, and while less time would be allowed for this item in larger numbers the amount allowed for the care of tools should be increased, both, of course, to be within reasonable limits. For larger numbers an allowance of 10 per cent of the machining time is made. An allowance for "extras" or unexpected delays of 25 per cent for one piece, dropping to 10 per cent of the total time for large numbers, is made. The matter of setting up the machine will fade to insignificance if five hundred or a thousand pieces are made.

There is still another way to consider a piece of work which is to be estimated. Shall we figure for the time in which it will be done, or for the time in which it can be done? The figures shown are estimated according to the first, with a consideration for the legitimate causes for loss of time. If the latter or record time is to be figured, less time would be allowed for setting up, fractions would be treated with more respect, and no "extras" would be allowed.

Another class, among the many classes of work performed upon these semi-automatic turret machines, is bevel gears, and here again the varying conditions admit of no rule. It is largely a matter of special tools, the number, efficiency and quality of which are dictated by the quality and quantity of the work to be performed. More time must be allowed for setting up because of their weight and the greater difficulty of setting the cutters properly in these tools; also their care. On some of this class of work an automatic feed can be used, on others a hand feed must be used. After the turret with its tools are in operation, about one-fourth minute is the amount to be allowed "from tool to tool." An extra amount must be allowed for putting a piece into a machine and truing it up and also for taking it out, if it is not made from bar stock. When bar stock is used it is cut off and drops and can be picked up and laid aside when the next cut is being taken, therefore no time is granted for this. With separate pieces this is not true, as the piece must be secured in jaws or a fixture and be taken from them in separate operations.

The automatic screw machine is more certain to figure upon as it loses no time through its individuality (speaking of a good quality of machine). In certain classes of work, however, it is much slower than the hand machine, because, not being intelligent, it cannot take advantage of small spaces and does considerable air cutting; it recognizes no differences or sand spots in the stock, etc., and it does not swing the tools into place as rapidly in small work. In other words, an automatic machine can lose time automatically as well as to save it. When these machines are run in "batteries" another element enters. Where four of these machines are kept in operation by one man, twenty minutes per running hour is liberal to allow for each machine. Excepting in special cases, about the same time must be figured upon for five machines as for four since the gain is nearly counterbalanced by the losses. When three machines are operated the individual difficulties or characteristics of the work itself begin to become more pronounced, but in general about fifteen minutes per running hour is safe for conservative estimates. The writer will not enter further into the troubles an estimator may find laid up for him when attempting to figure upon from five to ten machines with one or two operators. What has been said above regarding the automatic screw machines might also be reiterated of automatic gear cutters, particularly if the run of work is small in size and the number of pieces reasonably large, requiring frequent changing, but few "settings up" of the machines.

In small lathe work the actual machining of parts can of course be easily figured. Where the pieces are light enough to be handled and put in on centers, a half minute is sufficient for putting in and another for taking out. If arbors are used, from one to two minutes (ordinarily) are allowed, according to the piece and the position of the arbor press. Here, as with the hand screw machine, we allow 10 per cent loss of time for a journeyman and an additional 25 per cent as an average for an apprentice. The latter figure will make many people say funny things, and they can immediately point to boys of whom this is not true; so can the writer. It is a figure which would be much less in a small shop or department where much care and attention can be given and much more where the department is large and little or no attention is paid to the apprentice beyond what he can pick up from his fellow workmen with an occasional hint from the foreman when his turn comes. For obtaining roughing sizes one-half minute is allowed and for finishing sizes one minute. This time should be sufficient to cover the care of ordinary turning tools, and is usually found to be liberal for direct measurements.

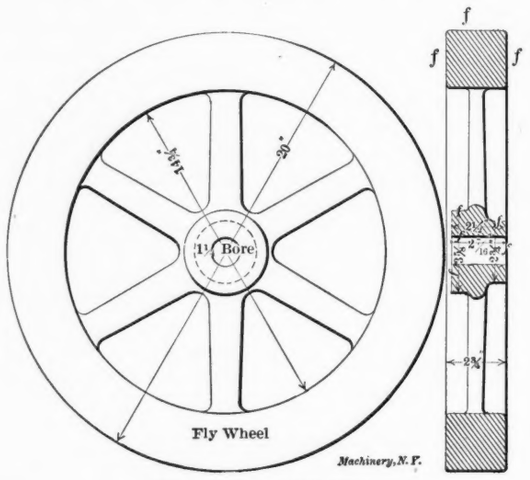



Fig. 2. A Boring Mill Job.

In figuring work for boring and turning mills the figures depend upon the machine having a double or a single head, as to whether it is a side head mill, power-handled, equipped with brakes and speed devices, or not. A knowledge of the quality of finish is absolutely essential for anything like intelligent estimating. The writer got into serious trouble on one occasion because of the meager information furnished (the details are given below). Forty-five minutes were estimated for doing a certain piece of work. The interested parties replied in a somewhat sarcastic vein that these pieces were done by them now in thirty-five minutes, and they were not satisfied with that. A representative called upon them and with information thus obtained found that the piece could have been done in about twenty-five minutes. A first-class finish and a particular job had been figured upon when a single roughing cut of fully ⅛-inch feed would have done. Here is the original estimate, based upon fifty pieces, speeds of from twenty to fifty feet per minute and feeds of from 1-16 inch to ¼ inch per revolution.

| | Min. |
|---|---|
| Set up machine (average) | 1 |
| Set piece in machine | 2 |
| Rough O. D. | 5 |
| Rough both rims (special tool) | 8 |
| Finish both rims and face (special tool) | 6 |
| Take from machine | 1 |
| Reset machine and piece (average) | 2 |
| Face, turn and round hub | 3 |
| Take from machine | 1 |
| For sizes and grinding tools | 12 |
| Extras | 4 |
| | 45 |

The following is the estimate based upon the information later at hand:

| | Min. |
|---|---|
| Set up machine (average) | 1 |
| Set up piece | 2 |
| Rough O. D. | 5 |
| Rough rims (special tool) | 6 |
| Take from machine | 1 |
| Reset machine and piece (average) | 2 |

| | Min. |
|---|---|
| Face and rough hub | 1 |
| Take from machine | 1 |
| Sizes | 4 |
| Extras | 2 |
| | 25 |

It will be noted that some operations are not mentioned. These were done at the same time that others were being done, therefore no mention is made of them.

The following is an estimate upon some double cylinders, shown in Fig. 3:

| | Min. |
|---|---|
| Set up machine (average) | 2 |
| Set piece in machine | 5 |
| Bore (2 cylinders, 2 cuts, 1-16 feed at 40 feet) | 30 |
| Facing (2 cylinder) | 2 |
| Chamfer (2 cylinder) | 2 |
| Sizes, etc. | 9 |
| Take from machine | 1 |
| Change from cylinder to cylinder (special fixture) | 2 |
| Extras | 6 |
| | 59 |

Allow one hour.

There are all kinds of slide rules to be used in this work and all sorts of complicated diagrams which are great time savers to those who are constantly using them and are in practice, but for the most a few simple tables for different materials, comprehensive at a glance, such as for cutting areas at different feeds and speeds, for gear cutting, for chucking, drilling, etc., are all that are needed. A dozen or two slide rules and diagrams might help some of us the way old Jones, the bookkeeper, was helped by an adding machine. Jones always came home regularly at 5 o'clock for a great many years. His employer was persuaded to put a new adding machine into the office for Jones's use.

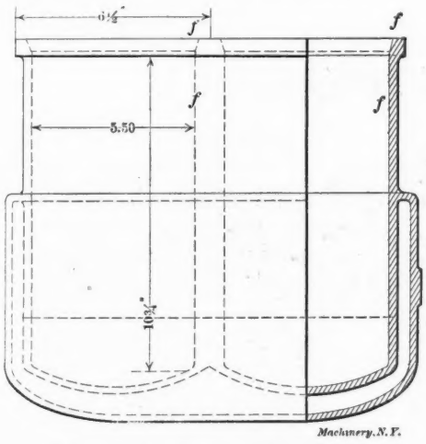



Fig. 3. Double Gasoline Engine Cylinder.

Jones used it and did not show up at his home until after 6 o'clock for several nights. Jones's wife inquired the reason for this unusual occurrence, and he replied that "the boss" had gotten him a "new fangled" adding machine, and he had to foot the columns afterward to see if they were correct.

A person must be familiar with the work and the methods which ought to be employed in handling it, the capacity of the machine to do the work, the relation of one operation to another which is to follow, and above all, the use of common sense and good judgment ahead of all rules and regulations.

The foregoing hints at methods rather than attempting to cover with definite figures a subject of such breadth.

* * *

After a thorough investigation of reasons for the lack of endurance of fence wire manufactured in the last few years as compared with the superior wire of twenty years ago, the Department of Agriculture at Washington has concluded that electrolysis is responsible for most of the trouble. The wire now put out, the expert of the department says, contains magnesia unequally distributed. This forms a resistance to the passage of electricity, and hence follows the electrolysis. Much of the wire manufactured to-day lasts but five years, while but a short time ago it was not uncommon for fence wire to be serviceable for twenty years.

## LABORATORY TRAINING.

C. H. BENJAMIN.

The use of laboratories in the training of mechanical engineers is comparatively a new development.

I remember in my own college experience Rankine's "Steam Engine and Other Prime Movers" in the class room, the drawing of beautifully tinted engines, copied from some textbook, and the taking of diagrams with a Richard's indicator from the one small engine owned by the institution. This last performance was my sole training in laboratory practice. As a matter of fact, the engine was not connected with any steam line until several years after its purchase and the indicator practice was imaginary.

During the past ten years the engineering laboratory has developed rapidly, and is now generally recognized as the most important agent in the instruction of mechanical engineers. The function of laboratory apparatus and machinery is twofold—to illustrate natural phenomena and the laws governing matter and force, and to train the student in the actual manipulation of such instruments, machines and engines as are naturally connected with his intended profession.

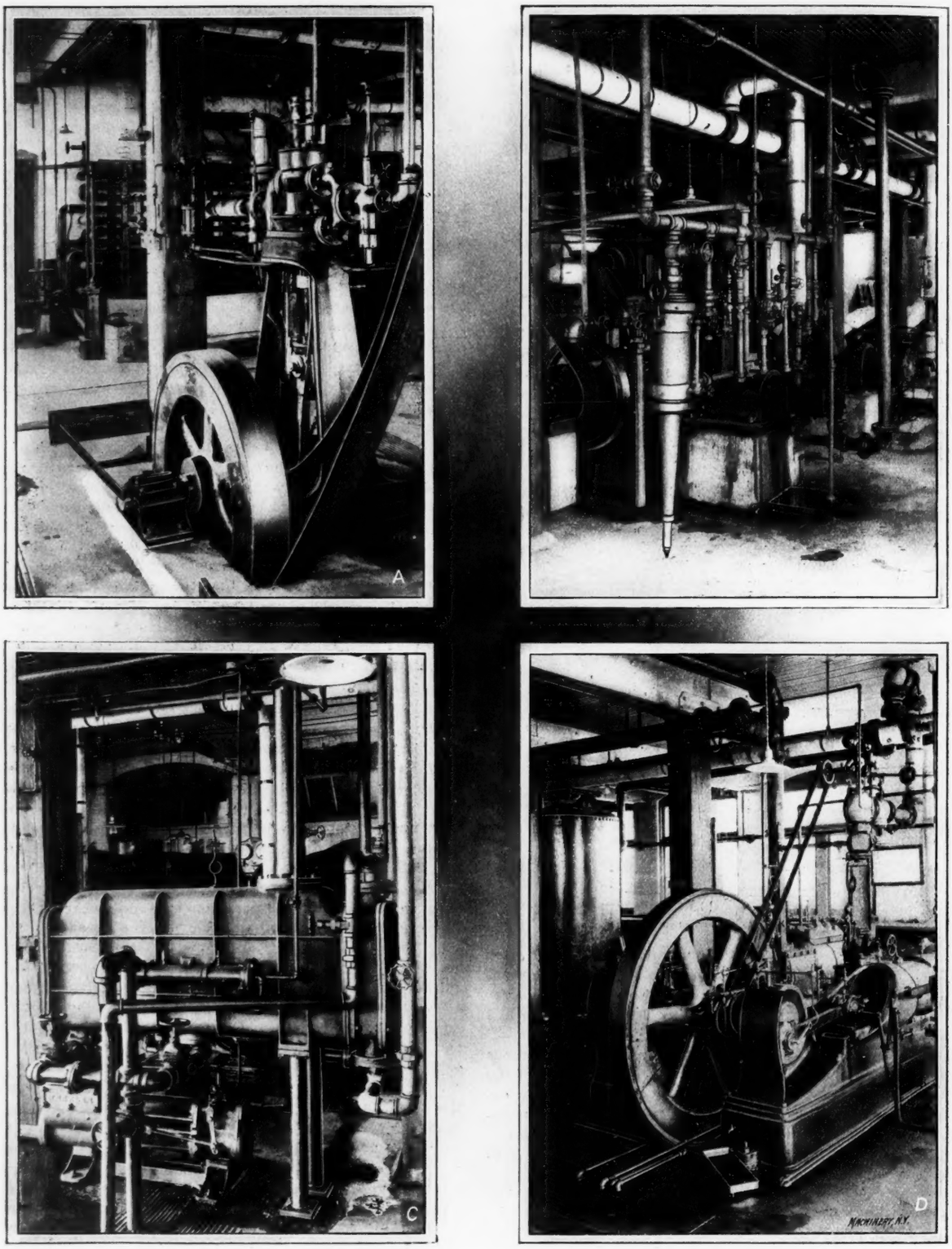
The old-fashioned physical or chemical laboratory with its array of apparatus for the sole use of the lecturer had the former function. The latter is, or should be, the function of the modern laboratory, be it physical, chemical, engineering, or what not; at least a place where the student may take things in his own hands and *do* with them.

There is a present-day demand for young men who know things and who know how to do things. There is also a demand for young men who can think *new* things. It is the function of the technical school to supply these demands, and the laboratory is the most important agent in doing this. Certain laws and principles are enunciated in the classroom or are worked out on paper in the drafting room, but it is in the laboratory, if ever, that the student is convinced of their truth. One physicist remarked to me recently that he was tired of seeing students rediscover known laws, but after all that is what each of us must do, in one way or another. A man's faith in either religion or mechanics comes by practice, and a paper faith is easily torn.

A laboratory, then, should be so equipped and officered that it may solve the problems of every-day engineering practice. And first, it should contain real machines and real engines. As far as possible these should be of ordinary commercial types, such as the student is likely to meet after graduation. An engine built specially for a laboratory and resembling no other engine gives false impressions and handicaps the experimenter. Second, the student should understand the machine and know the reason for every detail of construction. It is entirely possible for some students to make efficiency tests on an engine and not know the difference between a crosshead and stuffingbox. Third, the student should learn how to care for and how to run each engine or boiler or machine, and this knowledge should be acquired by continued practice under the supervision of a competent engineer. It may seem unnecessary to call attention to this, but in some laboratories it is not done, and some technical graduates know no more about running an engine or firing a boiler than they have learned by observation. Fourth, the would-be engineer should learn how to make the ordinary commercial efficiency tests according to the generally accepted standards and how to calibrate accurately the apparatus used in making such tests.

There has been considerable discussion of late as to the advisability of using printed forms and instructions in the laboratory. There is no doubt that the use of such forms has been abused in some instances, so that too little was left to the judgment of the student. I have seen printed logs for use in an engine test in which all the calculations were detailed, even the logarithms being located and nothing being left to the observer except the setting down of the data and the results in the blank spaces reserved for them. On the other hand, to attempt to teach the beginner how to make a standard evaporative test on a boiler or a standard efficiency test on a compound engine, without the use of printed forms to guide him, would be a sinful waste of time and would usually

entail slipshod work. In all so-called commercial tests for efficiency the printed logs and report blanks should be used as a means of training the student in the accepted methods for conducting such tests, but helps to calculation should be omitted. In the minor experiments, such as the calibration of gages and indicators, the log and report consist merely of sheets ruled in columns with appropriate headings. Fifth, the student should make such original investigations as the state of the art and the apparatus in the laboratory may warrant.




A.—Ice Machine, Ammonia Compressor and Condensing Coil.
B.—Apparatus for Testing Steam Engines.
C.—Condensing Apparatus and Vacuum Gage Tester.
D.—Ingersoll-Sergeant Air Compressor and Receiver.

FIG. 1. VIEWS IN ENGINEERING LABORATORY OF CASE SCHOOL OF APPLIED SCIENCE.

There are so many problems awaiting experimental investigation that student or instructor need never be at a loss for subjects. Neither does the laboratory need to be elaborately equipped for this class of work. Given steam or air or gas, some piping and engines of some sort and the ingenious investigator will improvise his apparatus as he goes along.

Here is where the originality and the independence come in. No printed forms, no set rules, no exact order of procedure is now possible. The path is a new one—sometimes not even a blazed trail—and the experimenter must feel his way. He may or he may not solve the problem, he may or he may not produce anything for the benefit of the engineering world, but

the work will have benefited him and given him a training of hand and eye and mind which he never could have acquired in traveling the beaten paths of the ordinary laboratory practice. At the same time, without the preliminary training in the most direct and efficient methods of laboratory work, which he has acquired by the use of rules and forms, he would be at a great disadvantage in this new and broader field.

Americans have been criticised for their lavish expenditure in apparatus and meager supply of instructors, and the criticism is a just one. Most laboratories would be improved by exchanging some of the machines for good teachers. But what shall we do? It is much easier to get $10,000 for new apparatus than $50,000 to endow a professorship. Shall we refuse the apparatus or shall we accept it and do the best we can under the circumstances? And then, the modern technical school is sadly embarassed by its wealth of students. For every hundred dollars received for tuition it costs two or three hundred dollars for education and the more students the greater poverty. Shall we turn away the applicants or shall we take them and again do the best we can?

One instructor to every machine and to every five or ten students is an ideal arrangement, but how shall it be brought about? None of us can do the quality of work we did in the old days when the class in mechanical engineering numbered four or five men and the professor knew each one by heart.

I would like to describe briefly the power laboratory of the Case School and indicate how it is being used, as an example to illustrate what has just been said.

The building is of brick in the so-called slow-burning or factory type of construction and has two floors, the lower for engines and heavy machinery, the upper for transmission machinery and apparatus of a lighter sort. The lower floor is 48 by 96 feet in dimensions, without any dividing walls, and is well lighted on three sides. The floor is of concrete so sloped as to drain toward the center line and is crossed by a system of underground conduits covered with removable iron plates, so that any water which is spilled finds its way by gravity to a trap located in a shallow cellar at one corner. All drips from the engines are carried in these same conduits. All clean water discharging from condensers or mains is collected in a hot well, located in the cellar, and pumped to the boilers.

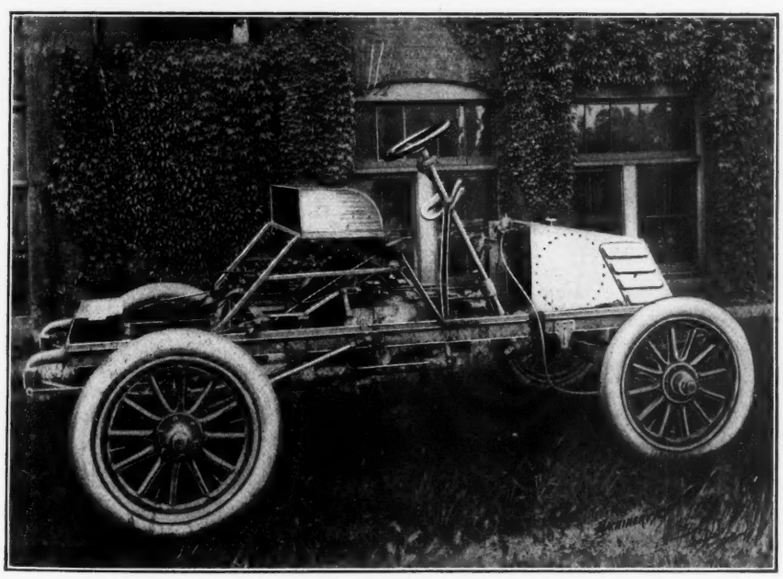


Fig. 3. Winton Chassis fitted for Road Test.

The boiler room adjoins the laboratory on the north and at present contains five boilers aggregating about 450 horse power. There are representatives of the horizontal fire tube and of the Babcock & Wilcox, Heine and Stirling water tube types; one of the boilers is equipped with a superheater and with induced draft. The Brightman, Babcock & Wilcox, Murphy, and Jones underfeed stokers are in use, and coal is handled by a traveling bucket with overhead trolley.

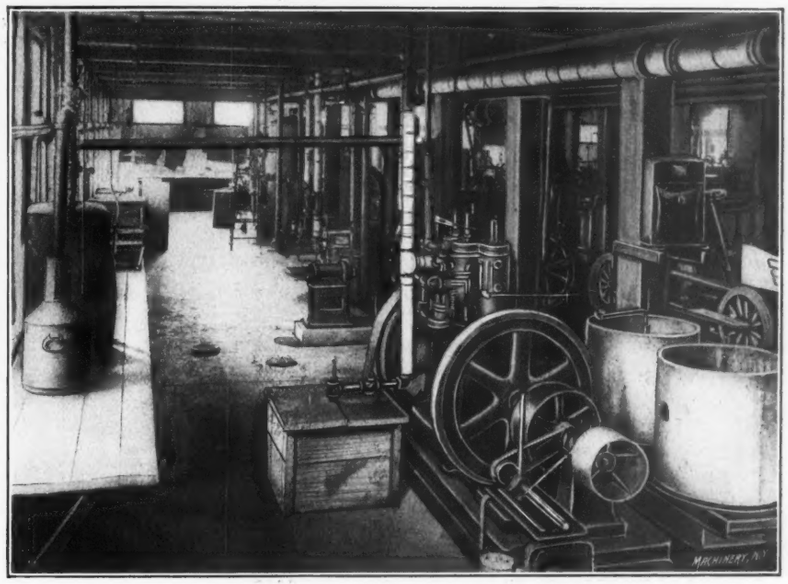


Fig. 2. General View of Laboratory.

A duplicate system of steam piping is used and there is a modern equipment of pumps, injectors, feed-water heaters and feed regulators. A system of galleries and ladders gives access to every part of the boilers for experimental work. Either saturated or superheated steam can be delivered to the laboratory and at any pressure up to 200 pounds.

In the laboratory is a special pump and feed-water heater equipped with measuring tanks and meters for use in testing the boilers, and these are entirely independent of the pumps and heaters used in daily work.

The laboratory proper consists of one large room unobstructed by partitions and having entrances at either end. Along the south and west sides run hardwood benches three feet from the floor, adapted for light experimental work and fitted with numerous steam and water connections.

The apparatus for calibration of indicators, gages and thermometers is on these benches. An Ingersoll-Sergeant compound, two-stage, air compressor, with air cylinders 12 and 18 by 12 inches, is used particularly for indicator work and for thermodynamic experiments on air and steam. The Porter-Allen engine, so piped as to be driven by steam or compressed air and equipped with an Alden brake, is also convenient for thermal and mechanical efficiency tests.

Two small steam engines are used for practice in valve setting and governor adjustment. One of them has a special attachment for measuring friction of steam packings. A Fairbanks-Morse single-cylinder, four-cycle gas engine and a Westinghouse two-cylinder gas engine afford opportunity for the study of gas and gasoline as motive powers. The Westinghouse engine is provided with gas and air meters and with apparatus for measuring the temperatures of the jacket water and the exhaust gases. Both engines are fitted with brakes and indicator motions. A tuning fork chronograph on the Westinghouse engine has made possible some very inter-

esting experiments on the fluctuations of speed during each revolution.

An Arctic ice machine of five tons' capacity, with compressor, condensing coils and brine tank complete, is equipped with special measuring apparatus and furnishes an excellent opportunity for research work in this very interesting field. The determination of the mechanical and thermal equivalents of a "ton of refrigeration" is a problem which can be worked out accurately with this apparatus.

Two small steam turbines, a 15 horse power De Laval and a 25 horse power Dow machine have been installed for high speed tests. Experimental work on the bursting strength of turbine disks is now under way.

The work which has already been done on flywheels, wooden pulleys and emery wheels has heretofore been noticed in these columns. A Winton gasoline motor car, the gift of the company, is used for efficiency tests. The machine is stripped of its upper works to make it accessible for experimental work and has a special form of water-cooled brake to measure the power developed. On the upper floor has been built a rolling track, similar to those used for locomotive testing, so that

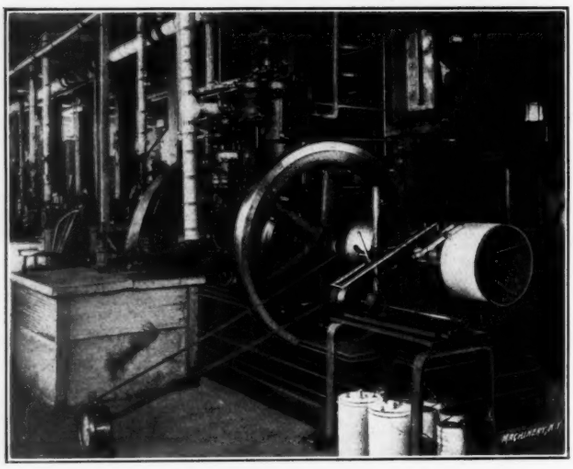


Fig. 4. Testing Westinghouse Gas Engine with Tuning Fork Chronograph.

automobiles may be run at full speed under road conditions and suitable measurements made of the horse power and the draw-bar pull.

The piping in the laboratory is rather complicated, as it must accommodate live and exhaust steam, hot and cold water, compressed air, coal gas and ammonia. All of the piping is overhead, the cross mains running between the floor beams above while the long mains run under the beams, so that there is no interference. A comprehensive color scheme is used in painting the pipes so as to differentiate the various fluids carried. The student soon learns that a blue pipe is cold and a yellow one hot and rarely confuses gas with steam or air.

Double steam mains accommodate saturated and superheated steam, while a duplicate system of exhaust piping makes it possible to run the engines condensing or non-condensing by the turn of a valve. The condensing main connects with a Wheeler surface condenser fitted with an independent air pump. Two additions to the equipment will probably be made within a few months: a 125 K. W. electrical unit, a high-speed engine and generator adapted to furnish power and lights on a three-wire system; and a 50 K. W. unit with an engine of the Corliss type for use as a reserve.

The laboratory training begins with indicator practice and the calibration of instruments followed by calorimeter and injector tests. The students take turns in running the various engines under the instruction of the engineer until they can be trusted to start up and run any machine alone. Each student has a week's practice in the boiler room where he learns the methods of firing the various boilers and stokers and the manipulation of the accessory machinery.

By the time the learner has progressed to the efficiency experiments and the commercial testing of the steam, gas or refrigerating plants he is able to run each plant and understand its operation.

## MILLING MACHINE FIXTURES.—4.

E. R. MARKHAM.

Vertical Spindle Milling.—When surfaces are to be machined flat it will be found more satisfactory and quicker, in many cases, to use an end mill of the proper design. The work may be held in a special vise or in an ordinary vise attached to the vertical face of an angle iron and done in an ordinary horizontal milling machine as indicated in Fig. 40.

The best results in vertical milling are obtained by using a vertical spindle milling machine, especially if heavy cuts are to be taken; but unless there is work enough to keep the vertical machine busy it is, generally speaking, advisable to buy a horizontal machine with a vertical attachment, since it is

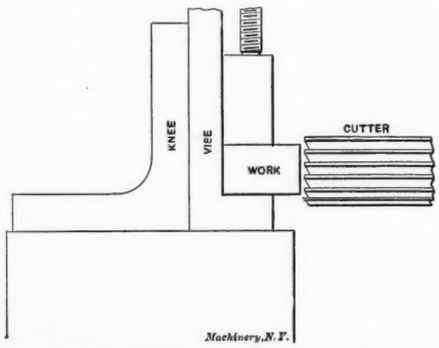



Fig 40. Using the End Mill on a Horizontal Machine.

possible to use the machine either way, as required. The fixtures for holding work when machining by this method will not differ materially from those already described. Fig. 41 represents a piece of work being machined by means of a vertical spindle attachment, the cutter being an end mill with inserted blades, cutting a block of 60 point carbon open hearth steel for a die block used in a drop hammer for drop forging work. These blocks were formerly planed but it is found possible to produce them much cheaper by milling.

Cams are applied to vises and special fixtures in a variety of ways and furnish a rapid means of binding the work in place. At times the cam is very simple, being on the end of a piece as shown in Fig. 42. If it is necessary to get considerable length of movement to the slide of fixture the cam may be made on a piece having a turned projection on its lower surface which fits in a hole in the base of the fixture. When it has been

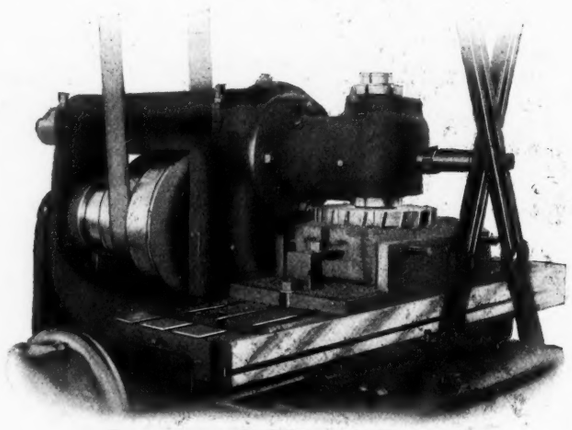


Fig. 41. The Vertical Milling Attachment.

turned sufficiently to relieve the pressure against the slide the cam may be lifted from the fixture and the slide moved as much as is necessary. After placing another piece of work in the fixture the slide may be moved against it, the projection on the cam inserted in the hole, and the necessary pressure applied by turning the cam.

Figure 43 shows a cam which is round in form and has a round projection which enters a hole in the fixture. This smaller projection is eccentric with the larger in which a hole is drilled and a lever inserted as shown. This, like the previous form, may be removable if desired. Cams of various

designs may be employed for holding work, the particular design depending on the piece to be held.

Binding Devices.—The method employed for holding work in the fixture depends of course on the nature of the work. Unless it is necessary to bind the work more securely than would be possible with a cam, it is not advisable to use a screw on account of the length of time wasted in turning it back and forth sufficiently to secure or free the work.

At times it is *necessary* to use a screw and it is found possible to save time by the use of a collar of the description shown in Figure 44. When the screw is turned back part of a turn the slotted collar may be removed and the work taken

FIG.42

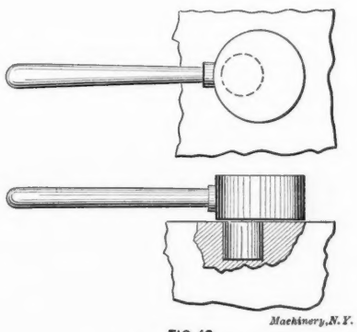



FIG.43

**Cam Devices for Holding Work.**

out. After putting another piece in the fixture the collar is placed on the screw *under* the head, and the screw tightened to give the desired effect.

Figure 46 shows a method, some modification of which may be employed to hold work when it would not do to have any screw heads or other devices projecting above the strap. When pressure is applied by means of the screw the portion *a* is forced down onto the piece of work. The angle piece is hinged at *b* as shown. At times it is possible to substitute a cam for the screw and so lessen the time necessary to operate the device.

When forgings or castings are machined it is sometimes possible to take advantage of the beveled portions occasioned by the draft necessary to get the forging out of the die, or the pattern from the mold. If the amount of bevel ordinarily given is not ample to insure desired results a sufficient amount may be given when the die for the forging or the pattern is made. Figure 47 shows a fixture holding a casting by means of the beveled edges referred to.

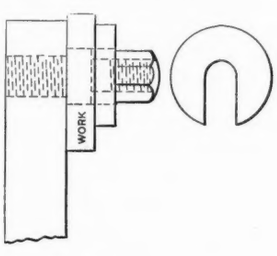



Fig. 44.

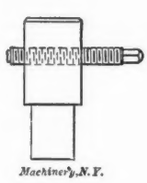



Fig. 45.

**The Slotted Collar and Removable Post.**

When such a method would bind the work sufficiently strong it is customary many times to use a screw having a right-hand thread on one end and a left-hand thread on the opposite end. Two applications of this principle are shown in Figure 48; at *A* the screw is held from moving lengthwise by means of the block *c* and the jaws are moved toward or away from each other by turning the screw. The jaw at the left, *a*, has a right-hand thread while the right-hand jaw, *b*, has a left-hand thread. This fixture is valuable when it is desirable to mill a slot, or a projection in the center of pieces which vary in width, and where the variation is immaterial. In the fixture *B* the jaw *a* is tapped with a left-hand thread and the stationary upright, *b*, with a right-hand thread. These threads being square in form may be of coarse pitch, thus causing the slide to move rapidly.

To save time it is customary at times to locate the binding screw in a removable post as shown in figure 45. When removing the work from the fixture the screw is turned sufficiently to relieve the pressure and the post lifted out of the

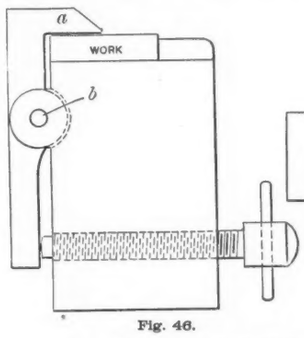



Fig. 46.

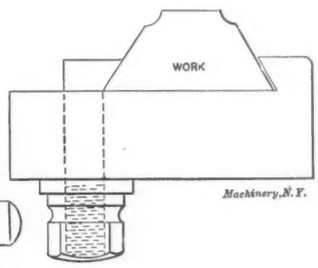



Fig. 47.

**Holding the Work where Head Room is Scant.**

hole, after which the work is removed from the fixture, the bearing surfaces cleaned, another piece put in place, the post again put in the hole and a partial turn of the screw binds it securely. In many instances if a screw were used in a stud securely fastened to the fixture it might be necessary to give it ten or a dozen turns before the work could be removed.

Figure 49 represents a device used for holding two pieces of work to be machined at the same time. Each piece rests against stationary portions *a a* of fixture, and is held in place by the swinging pieces *b b*, which are hinged at the center as shown, and are closed onto the work by means of the pointed screw *c* which passes through the stud *d*. This stud can turn in the hole in the fixture and so allow the point of the screw to swing somewhat to conform to any variation in the thickness of the pieces being held.

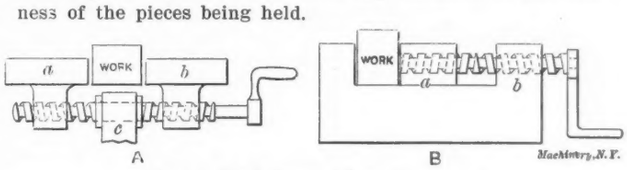



**Fig. 48. The Differential Screw Movement.**

When pieces have holes through them it is possible many times to take advantage of these in holding the work. Figure 50 represents a piece of work having on its upper portion a counterbored hole. A pin with a head a trifle smaller than the counterbored portion of hole extends down through the hole and through a hole in the fixture as shown. In the small end of the pin is a rectangular hole. Through this is driven a wedge-shaped key which draws the work solidly onto the seating surface of the fixture.

There are occasions when an ordinary cam would be objectionable and a screw would be too slow, and yet a combination of the two works nicely. Figure 51 represents such a binding device, and was used in holding a blank for a spring

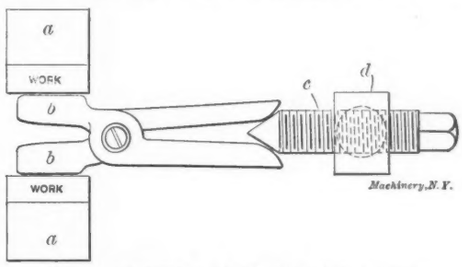



**Fig. 49. Holding two Pieces of Work at a Time.**

bow for a machinist's caliper while the ends were bent in a punch press. When the screw is turned down into the threaded hole in the base, the V-shaped projection under the head passing up the incline on upper portion of leaf forces it down onto the blank. When the projection on the screw reaches the flat portion at the top of the incline, the leaf has forced the blank down solidly to the bending fixture. If the

screw is turned more it, of course, continues to descend and draw the leaf down still more. The advantage of this combination is that if a cam does not pass around to a point at the end of the throw, it is apt to jar loose if subjected to vibration, whereas the projection under screw head passing up the incline acts as a cam, when it rests on the flat portion and continues to draw the leaf down as the screw goes into the

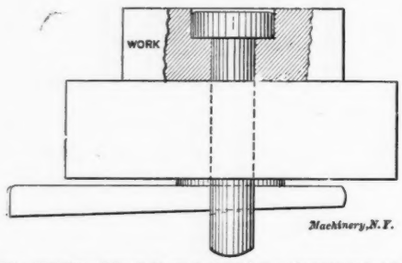



Fig. 50. Holding Work from below by a Counterbored Hole.

tapped hole. Although I have taken a fixture used on a punch press to illustrate an idea, I have applied the same holding device to fixtures for use on milling machines, but they were of such complicated design that it would appear to be folly to attempt to use any of them in illustrating this simple device.

I find that I have taken up a topic that might be enlarged upon, and articles written that would take up more space than would be wise to assign to any one subject.

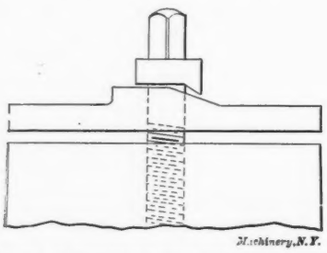



Fig. 51. A Combined Cam and Screw Clamp.

I have attempted to outline the fundamental principles, and to illustrate by means of simple fixtures and various forms of binding devices. The application must, of course, be left to the individual designer who should always bear in mind that simplicity is always preferable to elaboration, provided the simple thing insures the desired result.

* * *

Some one has figured out that if a college athlete could jump as far in proportion to his weight as the ordinary flea he could cover a distance of 1,100 feet at one leap, instead of say 25 feet at the most. We have not verified these figures and do not know whether they are susceptible of verification but would say that if a man were able to jump 1,100 feet his body would have to be made of something stronger than steel in order to stand the shock of striking the ground. If an ordinary man of average weight should jump 1,100 feet the shock would be so tremendous that his entire body would be reduced to pulp. The fact that the force of gravity is accumulative makes it quite improbable that a race of great giants ever existed, and by mere reasoning we can dispose of the fairy tales of men who were 100 feet or more high. If we can conceive of a man 60 feet high, for example, we must admit that he would weigh about 1,000 times as much as the average six-footer, if built in the same proportion. With this tremendous height an ordinary stumble, which would throw such a giant prostrate, would mean that his head would fall through a distance of 60 feet and it is not conceivable that any object of flesh and bone could stand such a shock without disorganization.

* * *

There is preserved at Barre, Vt., a surveyor's compass which may be the first ever made in America. It was built by Peregrine White, who was born on the Mayflower as the vessel lay off the coast waiting for a chance to make a landing. The compass is incased in hand-hammered brass, and the needle is said to point as true to-day as in the day of its maker.

## THE HISTORY OF THE MARINE TURBINE.

### FROM THE TURBINIA OF 1894 TO THE CARMANIA OF 1905.

The recent placing of the trans-Atlantic turbine steamer *Carmania* in commission and the successful completion of her first voyage on December 11 makes it of interest to review at this time the important work that has been done in the development of the marine steam turbine. Most of the turbines applied to the propulsion of vessels have been of the Parsons type, although some work of this character has been done both by Rateau and Curtis. In 1894 the Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne, England, was formed and the experimental boat *Turbinia* constructed. Her dimensions were 100 feet beam, 3 feet draught and 44 tons displacement. She was fitted with engines of 2,000 horse power with an expansive ratio of 150. There were three separate turbines —a high-, an intermediate-, and a low-pressure, each driving a screw shaft and on each shaft were keyed three propellers of small diameter. She attained a speed of over 34 knots and in 1896 tests made by Prof. Ewing, fifteen months after the vessel was completed, showed that the turbines had lost nothing in efficiency during that interval of time.

Various other high speed boats were built during the next five or six years which have been fully described in technical journals. Two of these, the *Viper* and *Cobra*, high speed torpedo boat destroyers, were unfortunately lost at sea and turbine propulsion received a serious setback. An organization was finally effected, however, which included the shipbuilding firm of Messrs. Denny, the Hon. Charles A. Parsons and Capt. John Williamson, which resulted in the first turbine steamer, *King Edward*, in 1901, for service on the Clyde.

The *King Edward* is a boat 250 feet long, 30 feet beam with 6 feet draft. The arrangement of the machinery is practically the same as has been used in all the more recent vessels, including the ocean liners, fitted with Parsons turbines. There are three separate turbines driving three screw shafts. The high-pressure turbine is placed on the center shaft and the two low-pressure turbines each drive one of the outer shafts. Inside the exhaust ends of each of the latter are placed the two astern turbines which rotate as one piece with the low pressure motors and when in operation reverse the direction of rotation of the low-pressure motors and outside shafts.

In ordinary going ahead steam from the boilers is admitted to the high-pressure turbine and after expanding about 5 times passes to the low-pressure turbines and is again expanded in them about 25 times and then passes to the condensers, the total expansion ratio being about 125 as compared with from 8 to 16 usual in triple expansion reciprocating engines of the marine type. At 20 knots the speed of the center shaft is 700 and of the two outer shafts 1,000 per minute.

When maneuvering in or out of harbor the outer shafts only are used and the steam is admitted by suitable valves directly into the low-pressure motors or into the reversing motors, for going ahead or astern. The high-pressure turbine under these circumstances revolves idly, its steam admission valve being closed and its connection with the low-pressure turbines being also closed by non-return valves.

This vessel met with success on the Clyde and her turbines are stated to have required no expenditure for maintenance and to have deteriorated in no way during five years of service. Mr. James Denny, one of her builders, estimated that the coal consumed was about 20 per cent less than if she had been fitted with reciprocating engines and paddle wheels.

In 1902 the *Queen Alexandria* was built for Clyde service. She differed from the *King Edward* in being slightly larger and in having more efficient reversing turbines. This boat formed the subject of a short report by Commander Walter F. Worthington, U. S. Navy, who writes as follows:

"Her owners have stated that the coal consumption is much less than that of a similar vessel fitted with triple-expansion engines, which they previously operated on the same service. The oil consumption is almost nothing, as the same oil is used over and over again; the total loss in three summers of about eighteen months' running having been but one gallon.

"The shafts, when carefully gaged, showed a wear of only

1/1000 of an inch the first summer and nothing the second summer. The tool marks still remain in the thrust collars. Metallic packing is used for all stuffing boxes. The stopping, backing and maneuvering of the engines was done quite as quickly and easily as could have been done with triple-expansion engines, all of the signals being answered promptly. The vacuum being constant, the speed called for was determined by the pressure shown on the gage attached to the H. P. valve chest, so that when, at any time, the captain signalled "half speed," for example, he always got the same number of revolutions and there was no delay or mistake due to attempting to count revolutions. The engines were run entirely by the pressures indicated on the gages. A dial and pointer were connected with each main engine shaft so that the direction and speed of the shaft could be observed if desired. In fact, that was the only way that one standing a short distance from the engines could know whether or not the engines were in use, as they made no noise whatever, and there was no sound of rushing steam, such as is heard in other engines."

In the *London Times* for Dec. 13, 1905, is an article by Mr. Parsons upon the history of the marine turbine from which the following statement of the more recent developments is taken in part:

The successful results of the *King Edward* and *Queen Alexandria* paved the way for the long list of similar turbine vessels, the cross-Channel boats commencing with the *Queen*, for the South-Eastern and Chatham Railway Company, plying between Dover and Calais, of which class of vessel 12 are now on service and six are building. Of these several vessels, we have the *Queen* carrying passengers from Dover to Calais at two knots greater speed and with 25 per cent less coal per passenger than any other vessel on the line, while the *Invicta* and the *Onward* turbine boats have since been added to the fleet with results surpassing those of the Queen. Again in 1904, on the Heysham Line to Ireland, the *Londonderry* and the *Manxman* turbine vessels beat their sister twin-screw vessels *Donegal* and *Antrim*, propelled with triple expansion reciprocating engines, by one knot, and lastly the *Viking*, built by Messrs. Armstrong, Whitworth & Co., plying from Liverpool to the Isle of Man, has consumed during the season exactly 25 per cent less coal per knot and is nearly two knots faster than any other vessel on this line.

About this time the third-class turbine cruiser *Amethyst* was built for the British Admiralty. She is 360 feet in length and of 3,000 tons displacement. Three other engine-driven cruisers of the same size were built simultaneously, one of which, the *Topaz*, was selected for a series of competitive trials with the *Amethyst*.

The contract speed of the vessels was 21¾ knots, and the results showed that at all speeds above 14½ knots the turbine vessel was the more economical, at 18 knots the turbine was 15 per cent more economical, at 20½ knots 31 per cent, at 22.1 knots 36 per cent, and at full power in each vessel the *Amethyst* showed 42 per cent more power than required by contract on the coal allowed; while the *Amethyst* reached 23.6 knots on the specified coal and the *Topaz* only 22.1 knots. In other words, the *Amethyst* has a radius of action at 20 knots speed of 3,600 nautical miles, while her sister vessels with ordinary engines can only steam 2,000 miles at the same speed.

### Atlantic Liners Fitted with Turbines.

Next we come to the Atlantic liners. The Allan liners *Virginian* and *Victorian* started to ply between Liverpool and Canada in the summer of 1905.

In April, 1905, Commander A. D. Canaga, United States Navy, was detailed to make the trip to Europe and return on the turbine steamer *Victorian* and report the results of his observation to the department.* There, unfortunately, is no similar vessel of the same line propelled by reciprocating engines with which a direct comparison can be made, but certain points brought out by Commander Canaga will be of interest. Figs. 1, 2 and 3 are reproduced from his report showing the arrangement of turbines in this vessel which is like that usually adopted for the Parsons' apparatus, and is practically the same as already described in connection with the *King Edward*. The steam from the boilers is led into the engine room through two 12-inch pipes uniting in the throttle valve at the working platform. From the throttle valve steam is lead through two 12-inch pipes to the high-pressure turbine.

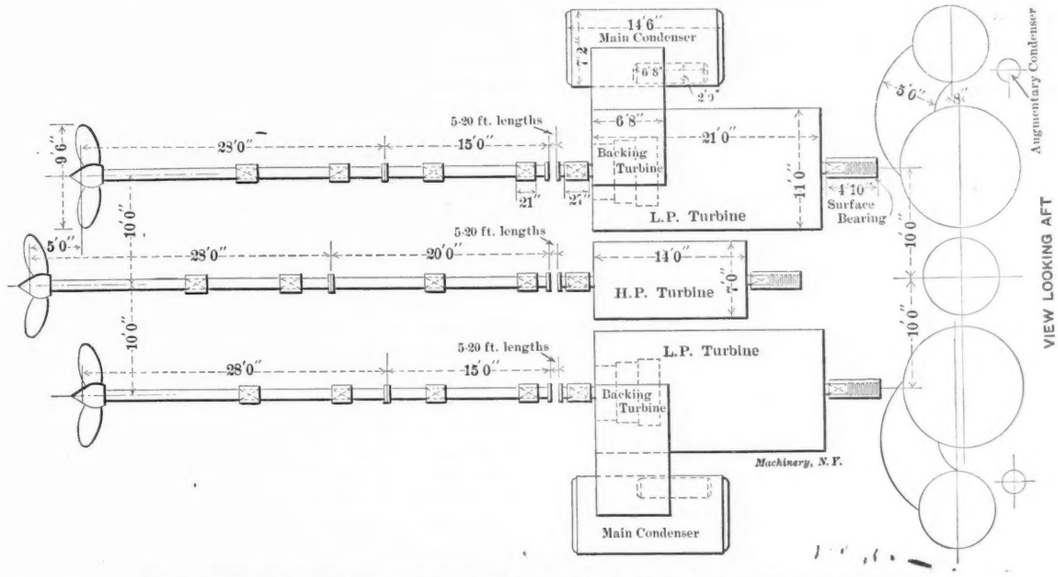



Fig. 1. Arrangement of Turbine and Propellers of the Atlantic Liners "Victorian" and "Virginian."

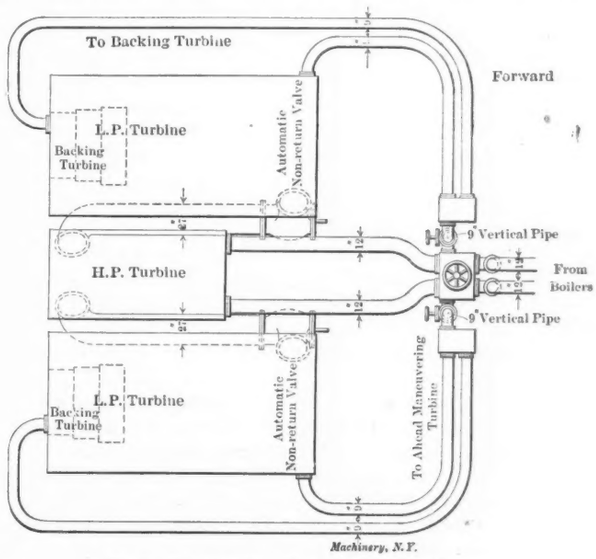



Fig. 2. Showing Pipe Connections of Turbines.

When in free route the steam is passed through the high-pressure turbine where it spreads, half going to the starboard and half to the port turbine through the receiver pipes, and thence through exhaust pipes to the main condensers. In maneuvering, the main throttle is closed and steam admitted to the maneuvering valves, Fig. 3, one for each low-pressure turbine. These are simple slide valves which when placed at the upper

* Journal American Society of Naval Engineers, August, 1904.

end of their stroke admit live steam to the forward end of the low pressure turbine, when at the bottom of their stroke admit live steam to the backing turbine, and when in mid-position shut the steam from both the ahead and backing turbines.

To prevent the steam blowing off into the high-pressure turbine when maneuvering, non-return valves are fitted in the receiver pipes between the high-pressure and low-pressure turbines, as shown in Fig. 2. These valves are automatic opening or closing as the live steam is admitted to the high-pressure or low-pressure turbines.

At the forward end of each turbine shaft is fitted a safety governor which in case of accident closes the main throttle valve. These governors serve another purpose, also, by indi-

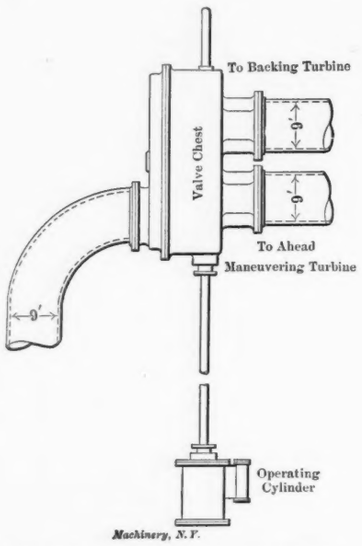



Fig. 3. Arrangement of Operating Valve.

cating whether the turbines are at rest or in motion, since from the working platform they are the only visible moving parts. The Commander reports that the turbines are easily and quickly handled and that the minor mishaps and annoyances met with in reciprocating engines are absent. He notes a pleasing absence of vibration and of racing in high seas. Against this immunity from racing, however, must be set the lack of holding power of the small screws with which turbine vessels must be equipped. It was observed that the influence of head winds and heavy seas reduced the vessel's speed considerably more than would have been the case with the large propellers used with reciprocating engines.

Attention is called to the fact that heating of bearings is a more serious matter with turbine machinery than with reciprocating engines as any unusual wear would cause interference between the rotating and stationary blades and on one of the trips the Victorian was delayed about 29 hours owing to some grit that got into one of the bearings and necessitated overhauling, after which, however, there was no trouble. There was also considerable difficulty from priming of the boilers but with consequences less serious than in the case of reciprocating engines.

The extension of turbine propulsion to still larger Atlantic lines was a question that early engaged the attention of the Cunard company and a committee of investigation was appointed, composed of representatives from the Admiralty, Lloyd's, and the leading shipbuilding and engineering firms and naval architects of England whose thorough investigation of the subject resulted in the recommendation of turbines for the large express Cunarders of 60,000 to 70,000 indicated horse power, and also for the Cunard liner *Carmania*, of 20,000 tons and 23,000 I.H.P., which has just been placed in service.

The investigations of the Cunard Committee comprised comparative tests on land of large turbines driving dynamos with similar reciprocating plants at various rates of output; they also included comparative trials of the turbine vessel *Brighton* with the reciprocating-engined twin-screw vessel *Arundel* between Newhaven and Dieppe; the two vessels were run abreast, and the consumption of water taken in each vessel on both voyages, and in these trials the turbine easily beat the triple-expansion engine in economy of steaming.

### Comparison between Turbines and Reciprocating Engines

The best opportunity for comparing the performance of vessels fitted with turbines and engines has been afforded by the Midland Railway Company's four boats of the Heysham Line mentioned above. Of these, the *Londonderry* and *Manxman* have turbines and the *Antrim* and *Donegal* reciprocating engines. The *Londonderry*, *Antrim* and *Donegal* have the following dimensions: Length 330 feet, breadth 42 feet, depth 25 feet, 6 inches. The *Manxman* is of the same length and depth, but has a breadth of 43 feet. The turbine boat *Londonderry* carries 150 pounds boiler pressure and the others 200 pounds pressure. The engines of the *Antrim* and *Donegal* are of the triple-expansion type, differing only in details, and drive a single, three-bladed propeller. The turbines of the *Manxman* were designed for 25 per cent more power than those of the *Londonderry*, but are of similar construction and drive three three-bladed screws after the usual manner. All the boats have high-grade condensing apparatus, but the *Manxman* has in addition a Parsons vacuum augmenter, for producing a high vacuum.

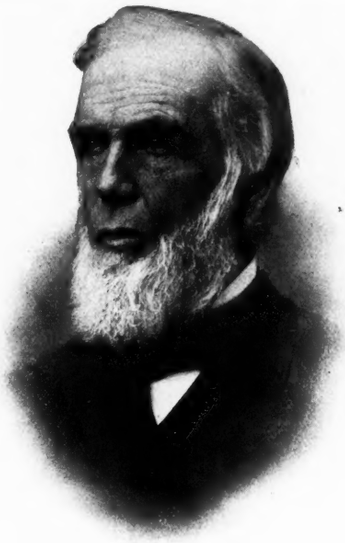
The results of the officials trials showed the two boats with reciprocating engines to be on a par in economy and to use practically the same amount of feed water under like conditions. At speeds of 19 to 20 knots, however, which is the working speed of all the vessels in service, the water consumption of the turbine steamer *Londonderry* was 8 per cent less and of the *Manxman* 14 per cent less than of the *Antrim* and *Donegal*, while throughout a speed range from 1 to 20 knots the turbine boats showed superior economy. Speed trials were run between the two turbine boats and the *Antrim* and the *Londonderry* proved about one knot faster and the *Manxman* from one to two knots faster than the *Antrim*, under like conditions.

Later, comparisons were instituted between the turbine steamers and those with reciprocating engines, based on the log books in which the daily records were kept while the boats were in regular service. During a part of this comparative period the *Manxman* was not on the same route as the other vessels so that she could not be consistently compared with the *Antrim* and *Donegal* during the entire time. Also, the high-pressure turbine of the *Londonderry* was partially wrecked owing to the blades of the rotating drum coming in contact with the stationary blades so that the records from this steamer were interrupted for three months. Valuable comparative figures were secured, however, and are summarized in table below. The regular route was between Heysham and Belfast, one vessel plying each way every night except Sunday. The comparisons are made in each case between vessels running in opposite directions on the same days and the table gives the weight of coal each vessel consumed on a given number of trips, exclusive of that burned when in port, which of course does not affect the performance of the propelling machinery.

TABLE SHOWING RESULTS OBTAINED BY STEAMERS RUNNING SIMULTANEOUSLY, BUT IN OPPOSITE DIRECTIONS.

| | Reciprocating Engines. | Turbines. |
|---|---|---|
| | Antrim. | Londonderry. |
| Number of Trips | 48 | 48 |
| Average Coal per Trip, tons | 35.6 | 35.3 |
| " Speed in knots | 19.7 | 19.5 |
| | Donegal | Londonderry. |
| Number of Trips | 42 | 42 |
| Average Coal per Trip, tons | 36 | 36.9 |
| " Speed in knots | 19.2 | 19.8 |
| | Antrim. | Manxman. |
| Number of Trips | 29 | 29 |
| Average Coal per Trip, tons | 38.6 | 38.6 |
| " Speed in knots | 19.5 | 20.3 |
| | Donegal. | Manxman. |
| Number of Trips | 39 | 39 |
| Average Coal per Trip, tons | 38.7 | 40.2 |
| " Speed in knots | 19.3 | 20.3 |

## REPRESENTATIVE AMERICAN MECHANICS.



BAXTER D. WHITNEY.

Baxter D. Whitney, the oldest manufacturer of woodworking machinery in America, was born in Winchendon, Mass., June 28, 1817. His father was a woollen manufacturer and in his childhood he spent much of his time in his father's mill. After attending school in his home town, with supplementary terms at Hancock, N. H., and Fitchburg, Mass., he went permanently into the shop to work for his father as a repair "man." While still a boy, the mill was having two cassimere looms made at the White & Boyden Machine Shop in Worcester, but so much difficulty was experienced in finding machinists capable of doing the work necessary on them, that the builders made very slow progress in filling the order. The elder Whitney, in order to help matters along, was asked to furnish a machinist to work on the looms, and the boy of thirteen was sent down to Worcester to do the work of a journeyman machinist. Having always worked for his father up to this time, he was naturally quite independent in his ways, and working for a stranger was new and rather puzzling to him. He relates with some amusement how he was given the job of polishing a number of cranks on a wooden wheel covered with emery. After he had finished the first one in good shape, he laid the job aside and started on something else, telling one of the proprietors when he came around to inquire into the matter, that he couldn't do them, there were "too many of them." There were probably ten or a dozen in the lot. After a little explanation on the part of the older man, however, the boy began to realize that it was sometimes necessary to keep at work even when the job was more or less monotonous. His wages at that time were $13 per month and board, Mr. White furnishing the board at his own house.

On his return to Winchendon, he again went to work for his father, doing all the repair work of the mill and building some new machinery. He gradually, however, drifted into business for himself, hiring space and power in a nearby shop and employing more or less workmen as conditions warranted. The books of the firm show that in 1836 there were twenty-nine men on the pay-roll. As time went on, he gradually left off working for his father and finally gave his full attention to his own business. The first machines which he made were those used in the manufacture of woollen cloth. Among them were a machine for cleaning the flocks out of teazels, a number of "steam jigs" and sixteen power looms, these last being built when he was twenty years old.

The town of Winchendon, which is situated at an elevation of about 1,100 feet in the hill district of central Massachusetts, was surrounded by dense forests of valuable timber, so Mr. Whitney's thoughts naturally turned toward the construction and improvement of machinery for working lumber into its various useful forms. Some of the early machinery he built was used in the manufacture of tubs and pails, a branch in which the firm has steadily kept a prominent position. A short time later he began to study on the cylindrical planer problem, and finally built a successful machine which was sold to a local firm. Cylindrical planers had been built before this time, but in none of them was it possible to plane a board without clipping the ends. In this first machine this was avoided by tipping up the front and back ends of the table and thus forcing the stock to bend in its passage through the machine, so keeping the ends down flat on the bed when entering and leaving the sphere of action of the knives. This arrangement is now, of course, obsolete, the "pressure bar," which is a feature of the present Whitney planer not having been invented until some time later. The old machine was used for a great many years, and is still preserved in one of the store rooms of the shop at Winchendon.

This wood working machinery, which was first built to meet local demands, soon began to attract attention from other sections of the country and orders came in more and more rapidly. Along in the middle of the forties Mr. Whitney determined to build a new shop for himself and go into business on a larger scale. Accordingly in 1845 he bought a water privilege near the center of the town and built the stone dam, fore-bay, etc., on the site of the ones which are now used for furnishing power for running the machine shop and lighting the town. In August of the same year his foundry was completed and iron melted, and the shop buildings finished so that by the end of the year the plant was in running order. Practically all of the machinery in this shop was home made. It was comprised principally of lathes, a drill press, and a planer with a platen about 36 feet long. The way in which the bed of this planer was levelled is interesting. Two long stringers built up of plank were laid down; to these were fastened the ways made in V-shape and cast in sections of about 8 feet long each. These ways were milled in a crude machine. The rough casting was fastened to a carefully straightened wooden plank which was free to slide in timber ways also carefully straightened and leveled. The milling cutter was mounted on a revolving arbor above the work, and the casting was fed against the formed cutter by a weight feed. The Cheshire Railroad was being built through the town at about this time and Mr. Whitney engaged the engineer in charge to level the ways of his planer for him, this being done with a level and rod in a way which suggests the methods now used by some firms in setting up work on the floorplate. After the stringers had been leveled as carefully as possible, the ways were bolted to them and these in turn were tested. At short intervals the top of the way was filed off until the surveyors' instruments showed all the spots to be parallel to the base line. After each side had been spotted in this manner, the ways were filed to a gage to bring the whole surface down even with the spots. Mr. Whitney relates that, desiring to test the accuracy of the engineer's work, he had him go over the job again after the filing was completed. He held the rod himself and at one point inserted under it a very thin pine shaving; the engineer made him stop, took a second sight, and remarked that he thought the casting was "just a little mite high." Mr. Whitney concluded that the job was reasonably well done. The table of this planer was driven by a rack and pinion, being different in that respect from most of the early machines, which received their motion from the winding and unwinding of a chain upon a drum.

From this time on the business rapidly grew in size and in reputation, improvements being made in their product constantly from year to year. Among the most notable of Mr. Whitney's contributions to the art of woodworking are his development of the cylinder planer, the invention of the gauge lathe, and the wood scraping machine. These machines were exhibited at a number of expositions in Europe and aroused a great deal of interest wherever they were shown, so much so that Mr. Whitney found in later expositions exact duplicates of his earlier machines being exhibited by European manufacturers. Up to within a few years ago, when Mr. Whitney was seized by a serious illness, he personally managed the business of the firm. Since that time he has, however, retired from active management and gives his entire time to preserving his health and vigor, and enjoying life in general. But, as may be imagined, a large part of his enjoyment in life is

still wrapped up in the business which he had fathered for so many years, so he is often to be found about the shop, watching the progress of the work, and interesting himself in the various improvements that are being made from day to day. So confirmed has this habit of improvement become in this establishment that a visitor will see very little to remind him that the business is seventy or more years old.

* * *

## THE DISCUSSION ON BEARINGS HELD AT THE DECEMBER MEETING OF THE A. S. M. E.

The discussion on bearings at the fall meeting of the A. S. M. E. brought together a large amount of valuable information on cylindrical and thrust bearings of the sliding, roller, and ball designs, and included discussions on the limits of pressure and speed, lubrication, thickness of oil film, cooling, and materials. Some of the important points covered are reviewed in the following paragraphs.

### Sliding Bearings.

A number of contributions were made descriptive of the practice of builders of various types of machinery. Mr. P. H. Been described the type of bearing used by a prominent Corliss engine builder. In proportioning the bearing the dead weight only of the parts supported is considered; that is to say, the weight of the shaft, flywheel, crank, connecting rod, etc., for a horizontal engine, and, in addition, the remaining reciprocating parts for a vertical engine. The pressure of the steam, presumably on account of its intermittent character, was not considered. Putting the general practice in the form suggested by Prof. Thurston a number of years ago, the product of the total pressure multiplied by the projected area of each journal would probably range between 60,000 and 78,000. One hundred and forty pounds per square inch is considered to be about the limit for unit pressure.

For shafts of ordinary size the bore of the bearing is made about 1-64 large. The castings are sometimes cored to allow the use of circulating water to prevent overheating, but where this provision is made it has been found in practice that its use is seldom necessary. The usual bearing material is babbitt, covering the entire bore and cast into dovetails and well hammered before being finished to size. A later method of lubrication is the system of flooding the bearings from a tank having a few feet head. By this method the oil is used over and over again and there seems to be rather less waste than when the oil is fed drop by drop. In the case of a 22 and 42 x 42 compound tandem Corliss engine connected to a generator, running at 100 revolutions per minute, 50 gallons of oil per day passed over the main outward bearings, using this method of lubrication. The day's run amounted to twenty hours; with the room at 92 degrees, the temperature of the bearings was constant at about 124 degrees.

Mr. George M. Basford gave some information relating to current practice in locomotive design. The conditions under which the locomotive works are so varying and so subject to incidental influences that it is practically impossible to approach the problem of bearing design from a purely analytical standpoint. If under severe working strains the unit pressure of any part of a journal box becomes so high that the oil is forced out from between the bearing surfaces, and the two metals come in contact, a hot box will result. General practice has agreed upon the following figures as giving reasonably satisfactory results.

TABLE 1. SAFE PRESSURES FOR LOCOMOTIVE BEARINGS.

| Location of Bearing. | Lbs. per sq. in. of Developed Area. | Nature of Service. |
|---|---|---|
| Crank Pin..... | 1,500 to 1,700 | Lubrication easy. |
| Wrist Pin..... | 4,000 | Rotation incomplete and intermittent. |
| Pass. Loco. Main .... | 190 | Lubrication difficult. |
| Freight Loco. Main.. | 200 | " " |
| Switch Loco. Main .. | 220 | " " |
| Car and Tender..... | 300 to 325 | Must be designed also to give safe fiber stress as a cantilever. |

These figures are not ironclad, but are always subject to the judgment of the designer.

Mr. George R. Henderson called attention to the effect of applying the load to a journal box eccentrically; there is an especial temptation to do this in locomotive design, since the gage of the track and consequently the distance between the hubs of the driving and truck wheels limits the extreme length possible over the bearings.

Let $P$ equal the load; $d$ the diameter of the journal; $l$ its length, and $p$ the unit pressure. Then will

$$p = \frac{P}{d\,l}$$

Supposing a driving journal to have been originally 10 inches in length and the diameter of the journal 8 inches. If the load is 16,000 pounds, uniformly distributed, the pressure would then be 200 pounds per square inch.

$$p = \frac{16{,}000}{8 \times 10} = 200.$$

Supposing the designer, to reduce this unit pressure, makes the journal 2 inches longer, but is not at the same time able to move the bearing on the spring rigging to a central position. If this, as in the first case, was still 5 inches from the outside edge, it would bear an inch away from the center line of the journal. Denote this eccentricity by the letter $x$, then will

$$x = 1.$$

Under these conditions the unit pressure at either edge of the box may be expressed thus:

$$p' = \frac{P}{d\,l} \pm \frac{P\,x}{\frac{1}{6}\,d\,l^2} = \frac{P}{d\,l}\left(1 \pm \frac{6\,x}{l}\right)$$

The positive sign refers to the edge nearest the load and the negative to the furthest edge. When the box is 12 inches long with the data previously given, this equation will figure out as follows:

$$p' = \frac{16.000}{8 \times 12}\left(1 + \frac{6}{12}\right) = 166\left(1 \pm \frac{1}{2}\right) = 249 \text{ or } 83$$

The larger value is the unit pressure at the outside edge and the smaller value that for the inside edge of the bearing. Thus, while the average pressure is only 166 pounds per square inch the lengthening of the box and the consequent eccentricity of the loading has increased the maximum pressure to 25 per cent more than with a journal 10 inches long and a central load. This might be so great as to prevent proper lubrication of the bearings at this point under running conditions. It is, then, generally preferable to get along with an increased unit pressure, rather than to create a condition of eccentric loading.

Mr. Joseph J. White described the box shown in Fig. 1, which was designed to meet the conditions necessary for a successful high-speed bearing for use on woodworking machinery. In a box held down by four bolts, according to the usual practice for such machinery, it is impossible to get a uniform pressure on the journal. By screwing the bolts down in turn a little at a time and then revolving the shaft to see if it runs freely, and easing up or tightening down until it appears to be all right, an approximately satisfactory adjustment may be obtained. If, however, this adjustment be made at all carelessly, the unit pressure near one of the bolts may be sufficient to break through the film of oil and bring the two bare metals into contact. In the box described by Mr. White and shown in Fig. 9, the cap, instead of being held down onto the journal, is tightened by another method. The rubbing surfaces are first fitted accurately to the shaft, the journal and boxes are oiled thoroughly and the cap is pressed in place by the hand. The film of oil not allowing the surfaces to come in contact, they are held apart by the amount necessary to give a satisfactory running condition. The cap is now clamped in place by the two horizontal bolts shown at each bearing, which grip it to the main casting by a sidewise pressure and do not, in so doing, disturb its alignment or change the allowance made for the lubricant. This box has been in successful use on woodworking machinery for twelve years, at speeds up to 4,000 and 5,000 revolutions per minute.

Mr. G. W. Dickie told of the practice followed in the design of marine thrust bearings, calling attention in his introductory remarks to the fact that the use of the Parsons turbine for propelling steamships was doing away with the necessity

for the old stepped bearing. The thrust of the engine is arranged to nearly balance the thrust of the screw, and the only function of the end bearing is then to take care of any comparatively slight excess of one over the other. The general practice for steady work allows about 75 pounds per square inch pressure with 500 feet per minute for average velocity of rubbing surface. This makes the P. V. constant about 37,500 pounds. For war vessels and severe service generally, this limit is considerably exceeded.

Mr. H. G. Reist gave some information relating to the well-known Curtis turbine foot bearing. Here the end of the shaft is supported by a film of oil pumped under it at high pressure. A shallow recess is worked out from the center of the bearing equal to about half of its area. From this recess the oil is distributed across the thrust surfaces. It has been found that it takes a greater pressure to raise the shaft with its attached parts than it does to support it after it has been raised. The oil pressure for the various sizes of turbines varies from 180 to 800 pounds per square inch, with the initial pressure, as explained above, about 25 per cent greater. The oil film varies from .003 to .005 inch in thickness. A table below gives some idea of the practice on three different sizes of machines.

TABLE 2. CURTIS TURBINE FOOT BEARINGS.

| | | | |
|---|---|---|---|
| Weight of Rotary Parts .. | 9,800 lbs. | 53,000 lbs. | 187,000 lbs. |
| Revolutions per minute... | 1,800 | 750 | 500 |
| Diam. of Bearing Seat.... | 9¾ ins. | 16 ins. | 22½ ins. |
| Pressure of Oil per sq. in.. | 180 lbs. | 420 lbs. | 650 lbs. |
| Quantity of Oil per min.... | 1 gal. | 3½ gals. | 6 gals. |

Albert Kingsbury reported some interesting tests made in 1904 by the Westinghouse Electric & Mfg. Co. at their East Pittsburg works. A horizontal shaft was used, supported on two bearings, each 9 inches in diameter by 30 inches long, with a third bearing 15 inches in diameter by 40 inches long midway between the supporting bearings. This gives a total of 540 square inches for the projected area of the end bearings, and 600 square inches for the projected area of the central bearing. The shaft was driven by a Westinghouse 150 horse power direct-current railway motor; the electric power supplied to the motor being the only available basis for estimating the friction. The test runs were of about seven hours' duration each, starting with all parts cooled and bringing the shaft up to full speed as quickly as possible. If the speed was run at once to 1,000 revolutions per minute, it was found that the expansion of the shaft and the inner part of the bearings caused binding, hence it was necessary to accelerate slowly, allowing at least three hours for heating the outer parts. In the final run, No. 13, two of the bearings were somewhat damaged, apparently from raising the speed too rapidly.

As will be seen from the table of data and results of the tests, it was found possible to run the bearings with loads and speeds greatly exceeding the ordinary values in practice, even without water cooling the bearing sleeve. The extreme case of a successful test is shown in column 12, in which a run was made under 94,000 pounds load at 1,243 revolutions per minute, with only a very small amount of water run through the bearing sleeve merely for determining its temperature. The oil supplied, however, was cooled in all the tests except in No. 7 and the first half of No. 13. The values for $P\,V$ in the various tests have been added for the sake of comparison with standard practice.

Several members contributed to the discussion of pressures, speeds, lubrication, cooling, and materials for sliding bearings. Mr. H. H. Suplee spoke of the necessity for distributing the metal in the bearing pedestal, not only with a view of giving it sufficient strength, but also designing it for the purpose of conducting the heat away from it as rapidly as possible. From this standpoint he criticised the practice of coring the box to allow the use of circulating water for cooling. The reduction in heat-carrying material brought about by the coring, the speaker claimed, was often the only thing that made water cooling necessary.

Mr. H. G. Reist described the practice of the General Electric Co. in proportioning journal bearings. The allowable pressure ranges from 30 to 80 pounds per square inch with a rubbing speed of from 400 to 1,200 feet per minute, the speeds and pressures being so proportioned that the maximum value for the P. V. constant does not exceed 50,000. The usual ratio of length to diameter is 3 to 1. For small and medium-sized bearings oil ring lubrication is used; above 12 inches in diameter the force feed plan is adopted. Rings must not be more than 8 inches apart. Thrust bearings are usually run submerged. Where it is impossible to get a proper area with a single thrust bearing the practice is sometimes followed of using a second surface with a spring suspension proportioned to carry about half the load.

Mr. John W. Upp gave additional information relating to the arrangement of the oil grooves in the bearings designed by the General Electric Co., and added the following table of allowances for oil in shafts of various sizes.

TABLE 4. ALLOWANCE FOR OIL.

| Diam. of Journal. | Allowance. | Diam of Journal. | Allowance. |
|---|---|---|---|
| Inches. | Inches. | Inches. | Inches. |
| ⅜ to 1 | .002 | 9 | .013 |
| 1⅛ to 2½ | .003 | 10 | .014 |
| 2¾ to 3½ | .004 | 11 | .015 |
| 4 to 4½ | .005 | 12 | .016 |
| 5 | .006 | 13 | .017 |
| 5½ | .007 | 14 | .018 |
| 6 | .009 | 15 | .019 |
| 7 | .011 | 16 to 24 | .020 |
| 8 | .012 | ..... | ..... |

### Roller Bearings.

Mr. Henry Hess, in speaking of the principles which control the design of ball and roller bearings, called attention to the antiquity of this method of reducing friction, and referred to the use which the ancient Egyptians and Assyrians made of rollers in transporting heavy masses of stone and building material. Continuing, he spoke of the influence of the bicycle in introducing the ball bearing to general use, and the disappointment which had attended attempts to employ it under more severe conditions. These disappointments led to a series of experiments by Prof. Stribeck, of the Neu-Babelsburg laboratory near Berlin, who came to the conclusion that sliding, roller, and ball bearings could be compared with each other

TABLE 3. TESTS OF 15″ x 40″ AND 9″ x 30″ BEARINGS.

| "A" and "C" — 9″ x 30″ "B" — 15″ x 40″ | Tests with Heavy Machine Oil. | | | | | | | | Tests with Paraffin Oil. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Test Number..... | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Pressure on B lbs. per sq. in. nom. Area. | 83 | 83 | 83 | 83 | 83 | 83 | 112 | 141 | 157 | 157 | 168 |
| Pressure on A and C lbs. per sq..... | 82 | 82 | 82 | 82 | 82 | 82 | 114 | 146 | 164 | 164 | 175 |
| Shaft Speed — R. P. M..... | 306 | 309 | 506 | 180 | 179 | 301 | 454 | 480 | 946 | 1243 | 1286 |
| Shaft Speed — Ft. per min. B .... .... | 1200 | 1215 | 1990 | 708 | 704 | 1180 | 1785 | 1890 | 3720 | 4900 | 5050 |
| Shaft Speed — Ft. per min. A and C.... | 720 | 730 | 1190 | 424 | 422 | 710 | 1070 | 1030 | 2220 | 2930 | 3030 |
| Friction H. P. Total for A B and C.... | 12 | 12.6 | 21.7 | 6.43 | 5.12 | 10.1 | 16. | 17.9 | 41.9 | 47.8 | 52.3 |
| Friction Torque lbs. ft. Total A, B & C. | 206 | 214 | 225 | 188 | 150 | 176 | 185 | 196 | 233 | 202 | 213 |
| Average coeff. of Friction for A B and C — Starting.. (cold) | .121 | .146 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Average coeff. of Friction for A B and C — Running.. | .0044 | .0045 | .0048 | .0040 | .0032 | .0037 | .0029 | .0024 | .0025 | .0022 | .0022 |
| Value of P V for B..... | 99,600 | 100,895 | 165,170 | 58,764 | 58,432 | 97,940 | 199,920 | 266,498 | 584,040 | 769,300 | 848,400 |
| Value of P V for A and C..... | 59,040 | 59,860 | 97,580 | 34,768 | 34,604 | 58,220 | 119,840 | 150,380 | 364,080 | 480 520 | 530 250 |

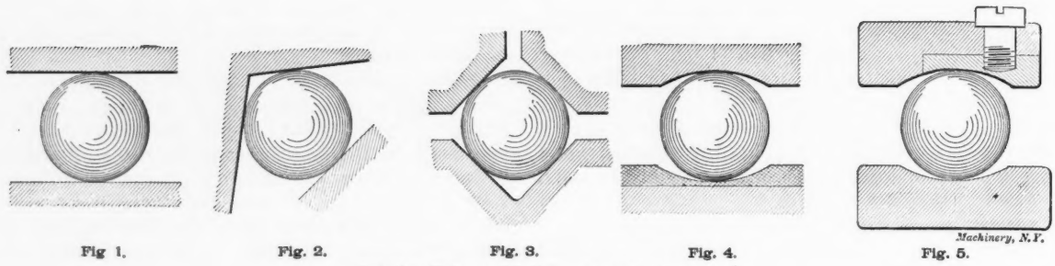



Fig 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

Relative Values of Ball Bearing Surfaces.

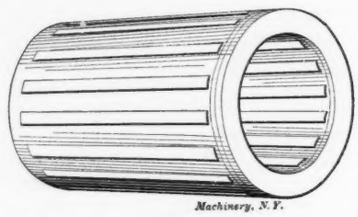



Fig. 6. Mossberg Roller Bearing.

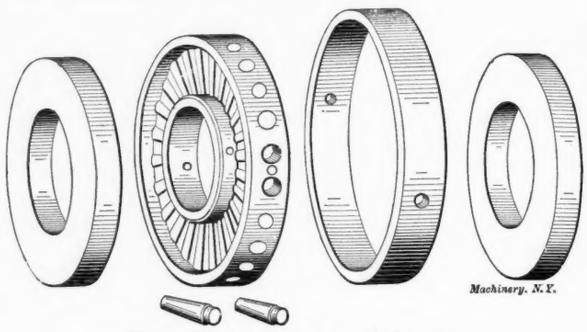



Fig. 7. Mossberg Roller Thrust Bearing.

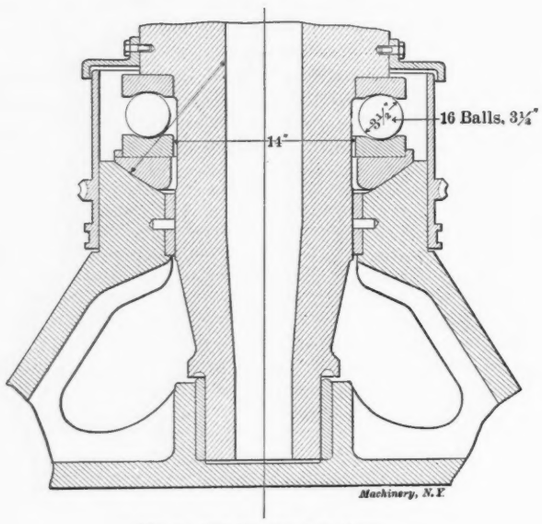



Fig. 8. Ball Bearing Gun Mount.

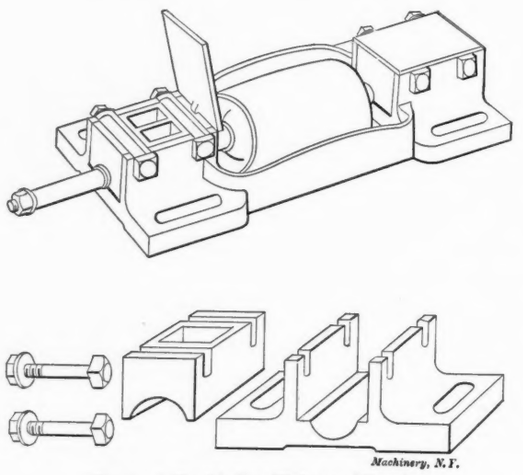



Fig. 9. A Non-binding High-speed Bearing.

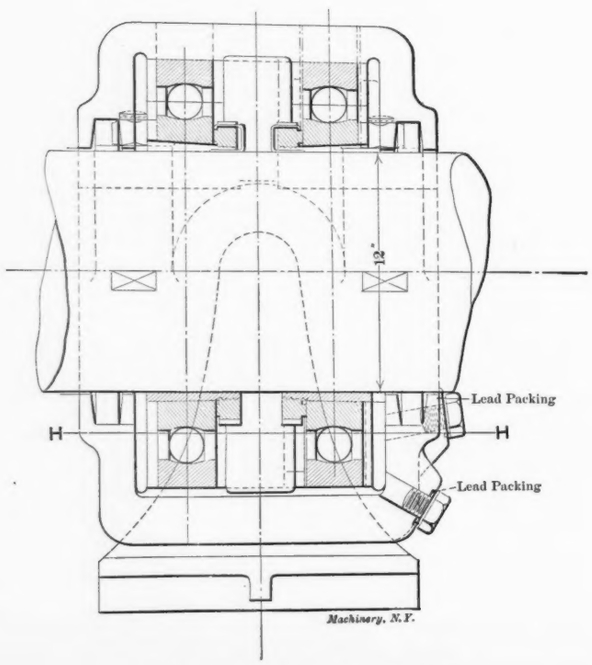



Fig 10. Double Equalized Ball Bearing.

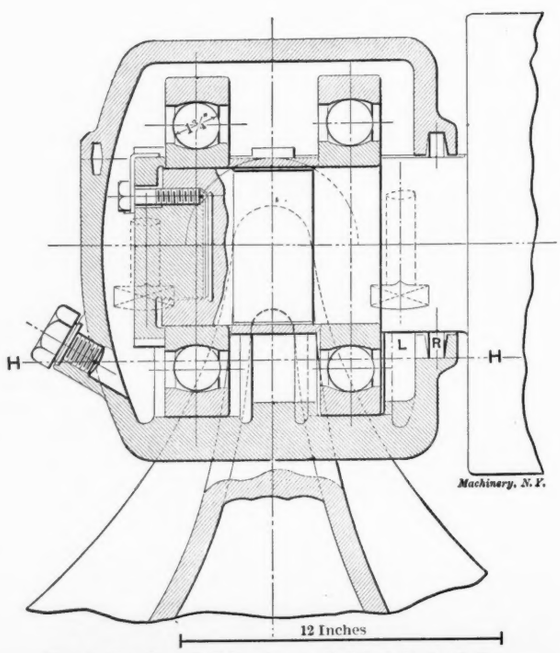



Fig 11. Equalized Ball Bearing applied to Calender Roll.

by reckoning the specific load of each in accordance with the following expressions:

TABLE 5. EQUIVALENT PROJECTED AREA OF BEARINGS.

Sliding Bearings..... Length of journal × diam. of journal.
Roller Bearings..... $\frac{1}{5}$ No. of rolls × roll length × roll diam.
Ball Bearings..... $\frac{1}{5}$ No. of balls × square of ball diam.

His tests showed that the co-efficient of friction for starting in the case of the roller bearing was not much greater than the co-efficient of friction when the parts were in motion. In the case of the ball bearing there is still less difference between the two co-efficients. This fact is important in the use of these bearings in the traction field, since here the power required for acceleration is usually greatly in excess of that required to keep the car or carriage in motion. The velocity of the ball or roller does not make great changes in the value of the co-efficient, within a wide range, wider for rolls than for balls. The experiments led to the conclusion that the proper specific load for roller bearings was from 6 to 11 kilograms per square centimeter, or from 85 to 155 pounds per square inch. The lower value should be used for soft rolls and shafts and the higher value when the rolling surfaces are all hardened and accurately ground. The design of roller bearings should be such that the rolls are free, of not too great length, and ground accurately, straight and true to size. Under these circumstances the rolls straighten themselves automatically as they leave the zone of pressure, doing this better than when confined in a cage.

Mr. Frank Mossberg gave particulars relating to the design and manufacture of the roller bearing which is known by his name. The principles he laid down are the result of a number of years' experience in the making of this form of bearing and differ in some interesting particulars from the ideas expressed by Mr. Hess. Mr. Mossberg's experience leads him to believe that since the contact between the roller and a journal or box is theoretically a line contact, it is not reasonable to increase the size of the rolls for the sake of increasing the capacity of the bearing. On the contrary, the rollers are made as small and numerous as the desired rigidity of construction will allow, the projected area of the journal covering at least seven rolls and preferably more. The length of the journal is made about 1½ times the diameter. The following table gives some particulars as to this line of roller bearings and Figs. 6 and 7 give some idea of the construction of two of the various styles.

TABLE 6. MOSSBERG ROLLER BEARINGS.

| Diameter of Journal. | Diameter of Rolls. | No. of Rolls. | Safe Load. |
|---|---|---|---|
| Inches. | Inches. | | Pounds. |
| 2 | $\frac{1}{4}$ | 20 | 3,500 |
| $2\frac{1}{2}$ | $\frac{5}{16}$ | 22 | 7,000 |
| 3 | $\frac{3}{8}$ | 22 | 13,000 |
| 4 | $\frac{7}{16}$ | 24 | 24,000 |
| 5 | $\frac{9}{16}$ | 24 | 37,000 |
| 6 | $\frac{11}{16}$ | 24 | 50,000 |
| 7 | $\frac{13}{16}$ | 22 | 70,000 |
| 8 | $\frac{7}{8}$ | 22 | 90,000 |
| 9 | 1 | 24 | 115,000 |
| 12 | $1\frac{1}{4}$ | 26 | 175,000 |
| 15 | $1\frac{3}{8}$ | 28 | 255,000 |
| 18 | $1\frac{3}{8}$ | 32 | 328,000 |
| 20 | $1\frac{1}{2}$ | 34 | 400,000 |
| 24 | $1\frac{1}{2}$ | 38 | 576,000 |

Again, as opposed to the principles expressed by Mr. Hess, the Mossberg bearing is confined in a cage, made as stiff and rigid as is practicable. The journal and shaft are of medium carbon steel, spring tempered. The outer shell is made very hard, of high carbon steel. The starting co-efficient for a bearing of this type is about .002; no figures have been obtained for a running co-efficient. This bearing has been very largely used for rolling mills, especially for cold rolling of precious metals.

### Ball Bearings.

Mr. Hess in the discussion on ball bearings continued the account of the experiments undertaken by Prof. Stribeck. While in a given space the roller bearing should be much more efficient than the ball bearing, there are practical difficulties in the way of utilizing the full efficiency of the roller. To get a uniform bearing the full length of the roll, its axis must in the first place lie exactly parallel with the axis of the journal as must also the axis of the box in which the bearing is contained. Again, the journal must not be so long that an appreciable amount of distortion takes place within its length. This will effect the uniform bearing of the roll on the surface of the box and journal. These considerations lead a second investigator, a Mr. Riebe, to believe that a ball bearing of such a design as to utilize to the last degree the capabilities of the materials of which its component parts were made, and using materials carefully selected for the functions they had to perform, would practically give better results than the theoretically more efficient roller bearing. Experiments were accordingly undertaken in the first place to determine the most efficient form of rolling surface for use with a ball bearing. Figs. 1, 2, 3, 4, and 5 show the different shapes experimented with. The arrangement shown in Fig. 1 develops the least amount of friction. Figs. 2 and 3 with three and four point bearings respectively develop a greater amount of friction without any corresponding increase in capacity. By confining the ball, as shown in Fig. 4 within a two point bearing composed of curves conforming rather closely to the outline of the ball, nearly as great efficiency was obtained as with the arrangement shown in Fig. 1, with a much greater carrying capacity. The contact between a perfect ball and a perfect planed surface or surface of greater curvature than its own, is theoretically in the form of a point. This predicates an infinite unit pressure at this point. This condition is of course practically impossible, the actual result being that the high pressure at this point jams together the metal of the ball and the race until a sufficient area of contact has been established to balance the strain due to the load, and the counter stresses which the physical characteristics of the parts affected are able to oppose to it. Since in Fig. 4 the ball is confined between surfaces approximating its own contour, this distortion for a given load is very much less than it would be were it rolling on a plane surface. Its capacity is consequently very much greater and, as before stated, its frictional resistance is nearly as small. Having determined the form of the bearing, experiments were next undertaken to determine the most suitable materials and the most suitable methods of treating these materials to give a high enough capacity to the bearing to make it unnecessary to use more than one set of balls. The accomplishment of this purpose makes it unnecessary in most cases to use more than a single set in a bearing. Fig. 5 shows the way the balls are inserted between the inner and outer races of a bearing of the type described. A filling piece is inserted in a groove of the race at a point where the ball is not under pressure, this filling piece being shaped to form a continuation of the race.

Mr. Hess showed a number of examples of the application of this type of bearing from which three only have been selected for illustration. Fig. 11 shows a double bearing as applied to the journal of a calendar roll. Since the pressure here is always in one direction, it is possible to use two bearings by mounting the box on a swivel to equalize the pressure between them. The bearings are thus unaffected by such distortion in the shaft as taken place between them. The load of this journal is 56,000 pounds. Some of the dimensions are given in the cut. Fig. 8 represents a gun mount which uses balls 3½ inches in diameter.

Mr. Eveland called attention to the impossibility of making balls of uniform size. In practice they are made as closely to standard dimensions as possible and then graded. Some manufacturers pack all which are about standard in one box, those .00025 inch larger in another and those .00025 inch smaller in a third, etc. Users are often ignorant of this practice and dump the contents of these three packages together indiscriminately. In grading the product in relation to its accuracy, manufacturers generally consider all balls which come with .00025 inch of the standard size as "quality A," all those which come within .001 to .002 inch of standard size "quality B," while for "high duty," balls of .0001 inch variation are selected. It is wiser to purchase balls of the manufacturer than of the dealer since the latter may not be able to resist the temptation to mix balls of different qualities together and sell them for the price of the highest.

Copyright, 1906, by THE INDUSTRIAL PRESS.

Entered at the Post-Office in New York City as Second-Class Mail Matter.

# MACHINERY

REGISTERED IN UNITED STATES PATENT OFFICE.

DESIGN—CONSTRUCTION—OPERATION.

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS,

66-70 WEST BROADWAY, NEW YORK CITY.

The receipt of a subscription is acknowledged by sending the current issue. Checks and money orders should be made to THE INDUSTRIAL PRESS. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Single copies can be obtained through any newsdealer.

We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

FEBRUARY, 1906.

PAID CIRCULATION FOR JANUARY, 1906,—24,627 COPIES.

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages. The Engineering Edition—$2.00 a year—contains all the matter in the Shop Edition and about 250 pages a year of additional matter, which includes a review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. RAILWAY MACHINERY, $2.00 a year, is a specialedition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

## AWARD OF PRIZES.

In the December number six prizes were offered, one of $20, one of $10 and four of $5 each, for the best and most practical suggestions for the improvement of the reading pages of MACHINERY.

The suggestion which in our judgment is entitled to the first prize has been made by two contestants and this prize is accordingly divided between them, making the awards as follows:

Divided first prize, John S. Myers, Philadelphia, Pa., and M. Joachimson, New York City, $10 each.

Second prize, E. W. Beardsley, Waterbury, Conn., $10.

Third prizes, W. H. Sargent, St. Johnsbury, Vt.; J. C. Steen, West Lynn, Mass.; Chas. H. Cross, Eau Claire, Wis.; and Wm. C. Terry, Pittsburg, Pa., $5 each.

* * *

## MACHINE SHOP DONT'S.

In this issue we give another list of machine shop don'ts compiled by Mr. H. E. Wood, believing that they express in small compass much that has to be learned by every good machinist, although of a negative nature. For when we pause to reflect the command "thou shalt not" seems to be a large part of human education in first principles generally. The child is cautioned not to go near the stove; not to play with knives; not to go in dangerous places; not to throw stones at windows, and not to do many other things, the doing of which is a menace to the comfort and well-being of himself and others. The decalogue itself is largely negative and the laws of all countries (except, perhaps, Russia), tell what a man must not do. In the case of the machine shop don'ts, many of them could have been expressed equally as well in the positive sense, but perhaps not so forcibly because of the peculiar quality of the average human mind that it seizes onto a fact and makes more of it when learned by inference than by direct telling. The philosophy of don'ts might be likened to danger signals on a highway where accidents are very likely to happen. It would be impracticable and foolish to put up signs on the straight course telling drivers to go in the middle of the road, etc., but it is pertinent at the danger points to put up notices that certain precautions should be observed if disaster is to be avoided. In short, we assume that human instincts are in general correct and that the minds of men proceed along sane and conservative ways but all are liable to make some mistakes and some of these may be pointed out to the young beginner—and the journeyman too, perhaps.

## BOILER PLANT ECONOMY.

In a paper contributed to the 1905 proceedings of the American Water Works Association by Charles A. Hague, which is abstracted in the *Engineering Review* of this number, attention is called to the discrepancy that usually exists between expert tests upon steam apparatus and the results of every-day operations. This difference is attributed to the difference in skill and painstaking care on the part of those who make the expert test and those who operate the station from day to day. While this condition exists to a considerable extent in respect to steam engines, it is in the boiler room where the greatest amount of money is lost in modern power plants. The steam engine has been subjected to all sorts of refinements, even to the extent of polishing the cylinder heads and the faces of the pistons to reduce initial condensation, and with reasonably good care they should operate regularly with fair economy. The boiler room, however, does not get so great a share of attention. The boiler setting cracks, the firemen are careless or ignorant, and the room is so dirty and hot that the engineer prefers not to spend a great deal of his time there. What may be done, however, by properly educating and placing the fireman under expert supervision and also by maintaining the boiler settings in good condition, is illustrated by the results accomplished by one of the largest public service corporations in this country. They have taken rigorous measures to maintain boiler room efficiency and have employed a chemist to analyze the chimney gases. The settings were made absolutely tight and the dampers and grates regulated in accordance with the analysis of the chimney gases. The results indicate that the first year 10 per cent or over $100,000 worth of coal will be saved. It is only by considering plants of this magnitude that the meaning of the loss existing to a less extent in smaller plants can be fully understood. The figures indicate, however, that in many smaller power houses it would pay to give more attention to the boiler room.

* * *

## ON PROMOTING INVENTIONS.

One of the difficult things for the editors of a technical paper to decide is the advisability of publishing descriptions of patented inventions which have not been perfected and placed on the market. Such descriptions benefit no one directly but the inventor, for no one can make and use the machine, because of the patents; and no one can purchase it, because it is not ready for the market. If the device is of unusual interest, however, from a mechanical standpoint, it may furnish interesting material for the reader, and it may be advisable to publish a description. But in any case it would seem to be outside the bounds of propriety to give space to an account of a machine that is in the infant stages of its development.

As a case in point, descriptions of a machine have recently been sent to the technical press for publication, which might easily give the impression that it has been so far perfected as to be already a practical success. The invention is a composing machine designed to compete with the Lanston Monotype, which latter consists of two machines that must operate in conjunction. One has a key-board like a typewriter and when the keys are depressed corresponding holes are punched in a roll of paper. The other casts and spaces the type under the guidance of the punched roll on the plan that a piano is operated by the perforated roll of an automatic piano player.

In accordance with our usual custom, we investigated the new machine and found that it was designed on a much simpler principle than the Lanston, but that, unfortunately, the working model was in no sense an operative machine, since several important parts of its mechanism have not yet been made to properly perform their functions. In short, the machine is largely on paper, although a considerable amount of experimenting has been carried on. The attempt to bring a machine in so incomplete a state prominently before the public, presumably with the expectation of raising capital to conduct further experiments, is not in our opinion the best policy, even for a promoter; and if a technical journal is to use such matter it should at least state the facts as they are so that no investor may be misled by published statements in a journal which he very likely looks upon as more or less of an authority.

# ENGINEERING REVIEW.

## CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

The inconvenience of referring to a map in the open air is so great as to preclude its use except in case of positive necessity. The *English Mechanic* refers to an invention called the microphotoscope, invented by a Berlin chemist, which though no larger than a cigar-case, permits of consulting the map of a whole district by night as well as by day, and in any kind of weather. The map is photographed in miniature on a plate of ground glass, which is illuminated by a small incandescent lamp supplied, when required, with current from a battery, while a lens can be adjusted to the observer's sight.

Gold should not be used in repairing platinum dishes since its melting point is materially lower than that of platinum, says the *Mining Reporter*. When the latter metal itself is used, the repaired dish is as good as new. To effect a good weld, brighten the surface to be repaired and cut a small piece of foil to fit the spot that has been damaged. Heat both to incandescence and place the patch in the proper position. Then, while white hot, the patch is tapped gently with a suitable small hammer until the weld is accomplished. Skillful workmanship will give a practically new dish or crucible.

One of the most difficult problems in civil engineering is to accurately gage the flow of rivers. It is hard to find just what the average rate of flow is, for the water travels faster at the surface than at the bottom or near the banks. An interesting method of gaging streams by chemical means was described in a paper presented before the Institute of Civil Engineers by Charles E. Stromeyer. It consists briefly of adding a certain quantity of brine to the stream and of taking at a point farther down samples which were subjected to very accurate analysis. The increase of salinity gave a factor by which it is possible to calculate the stream discharge with a possible error of less than 1 per cent.

An obituary of James C. Warner, who died in Chicago, November 14, 1906, was published in a recent issue of the *Western Electrician*, and it reveals a mechanical career of unusual interest. Mr. Warner was an expert mechanic of a type now rarely found, being an instrument maker, engraver and electrician. His father and grandfather before him were highly skilled mechanics and his son, Ernest P. Warner, has in his possession a lathe nearly 120 years old which was used by his grandfather. One of the most interesting facts connected with his life to the world at large is that he was employed in New York to make the first telegraph instruments used by Morse on the historical telegraph line between Washington and Baltimore.

A textile paper, in a short article on noisy gearing, says one of the details of construction that may cause noise is that the depth of the tooth spaces is not right. In this respect gears are more often cut too deep than not deep enough, and it is worse to have the driver too deep than the driven gear. Another cause of noise may be that the cutting is not central. This may be shown by gears being noisy in one direction and quiet when running in the other direction. Again, the center distance may not be right; if meshing too deep, the outer corners of the teeth of one gear may strike hard against the roots of the teeth of the other gear. Still another reason for noise may be found in the fact that the frame carrying the gear shafts may be of such form and size as to give off sound vibrations.

In an editorial on the centrifugal pump the *Practical Engineer* says in considering the advantages and disadvantages of turbine pumps that it is well to assume a general rule that where the head expressed in feet is greatly in excess of the quantity in gallons to be delivered, a reciprocating pump will give the better results. An example is given of a turbine pump built by well-known makers designed to deliver 500 gallons per minute against a head of 500 feet in which the efficiency is about 72 per cent. But the best efficiency possible with a turbine pump designated to deliver 50 gallons against the same head would only be about 60 per cent. In the latter case not only would the efficiency be reduced but the price of a turbine pump would doubtless be more than the best type of three-throw reciprocating pump.

The power of running water to move large blocks of stone is well illustrated at the Assouan Dam across the Nile, says the *London Globe*. A large mass of rock has been dislodged from the bed of the river by the powerful current issuing from the barrier, and thrown backward against the masonry. This boulder is 17 feet long by 12 feet broad, and 7 feet in thickness. It is estimated to weigh sixty tons. Geologists, who are perhaps too often apt to assume that any such large block separated from its parent mass must have been moved by ice, should take special notice of this. It was estimated by Mr. W. Hopkins, of Cambridge, England, that while a current of ten miles an hour might move a spherical mass of stone five tons in weight, a current of twenty miles an hour would move a block 64 times as heavy—that is to say, a weight of 320 tons.

A correspondent of *Power* gives an amusing example of prejudice in steam engineering practice and of truly wonderful gain in economy when that prejudice was satisfied. He had charge of the erection of a small steam-driven electrical plant and when it came to the exhaust pipe of the engine he arranged it so that it discharged horizontally over a small stream. This did not suit the ideas of the resident "engineers" and they unanimously agreed that the erector might be all right on electrical machinery but that he did not know much about steam engine practice. The owner of the plant was impressed by their talk and asked the erector if the engine would not work better if the exhaust pipe went up through the roof, to which emphatic reply was made that it would not. But when the plant was visited three or four weeks afterward the erector found to his surprise that the exhaust pipe had been changed to shoot the steam upward through the roof and learned with still greater surprise that the plant was operated with one-third less coal than before!

The great difficulties involved in establishing standard units of weights and measures are not always appreciated. In discussing the subject at a meeting of the American Water Works Association, Dr. W. P. Mason, of Rensselaer Polytechnic Institute, related the following incident: I very well remember some years ago of a boy stepping into my laboratory with a telegram coming from one of the officials of the Standard Oil Company. It read, "Wire us at once weight of a gallon of water in grains, four decimal places, at 60 degrees Fahrenheit." I said to the boy, "Just wait a minute, I will write a telegram." I thought it was the simplest thing imaginable to do. I couldn't understand why they had sent so simple a problem to me. All I had to do I thought was to go to my library and write the telegram at once. I didn't keep that boy waiting, because it took me just three months to write that telegram—and when I wrote it, it was not right. I found if I only had books enough I could get any kind of a result. The few authorities who agreed had taken the results from each other. I found as a matter of interest to me that there was but one pound fixed by statute in the United States, and that was the Troy pound, which had been brought from England for use in the Mint. It may be worth while stating that we now, in this country, possess the standard Troy pound. Years ago we sent a commission over to copy the English standard. They brought such copy here, and it is now in the mint at Philadelphia. Since then the British pound has been burned, so we possess the standard. That is the only weight except those of the metric system that is upon the statute books to-day, all other weights being recognized merely in common law.

## PLANER CLAMP.

In the November, 1905, issue a contributer described a planer clamp of the type having a pentagonal piece pivoted at one end to act as blocking of adjustable height. The same fixture, except that the block is a hexagon, was illustrated in a recent issue of *Portefeuille Economique Des Machines*, and with it was shown two applications of a similar device, but of somewhat different construction. This device is shown in Figs. 1 and 2, the block being in this case rectangular and with

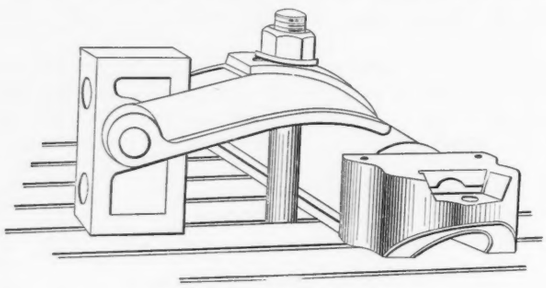


Fig. 1. The Device used as a Clamp.

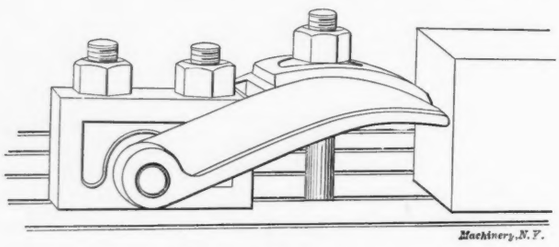



Fig. 2. Used as a Strut.

two holes drilled through to clamp it rigidly to the platen, as shown in Fig. 2. The clamp, it will be observed, is made with the pivot in such a position that the blocking has four different heights, according to the side on which it is laid. In two of these postions it can be bolted to the platen so that the clamp may be used as a strut against the side of the work as is desirable when planing a piece all over.

## ALLOWANCES FOR PRESSED FITS.

In making allowances for pressed fits, says Mr. S. M. Howell in *Popular Mechanics*, there should be a difference in size of from 0.002 to 0.003 inch for each inch of diameter. The required pressure in tons will be the allowance in thousandths multiplied by the diameter in inches and by 1½. It will be apparent that with pieces of very large size the necessary pressure would be very great indeed. An allowance of about 0.010 inch on these cases will be sufficient and would bring the required pressure within more convenient limits. It is also true that the driving allowance must in many cases be limited by the strain which the job will safely stand. The material and thickness of the metal which surrounds the hole, the length of the forced shaft, etc., these points are in some cases governing considerations. As a general thing, however, in ordinary cases when it is not necessary to go to extremes, the given rule of 0.002 inch per inch of diameter may be used on all work up to about 4 inches diameter. For larger pieces a total allowance of 0.008 to 0.010 inch per inch of diameter is about right, regardless of size. About 0.007 will make a 40-ton fit on a 4-inch axle. When the required pressure is specified, divide the pressure in tons by 1½ times the diameter, in inches. The quotient will be the required allowance in thousandths inch. For driving fits, a total allowance of 0.003 without regard to size is good practice with pieces larger than 1½ inch. For smaller pieces apply the first rule given for pressure fits and shrink fits. In making a press fit with an old wheel, which has been previously pressed on and off, the bore has been surface-hardened by the pressure to which it has already submitted, and the force required to press the wheel on will be about double that required for new work, or, the forcing allowance may be reduced to one-half regular amount.

## NEW OIL PUMPING PROCESS.

The Southern Pacific Co. is soon to make a test of a new pipe line pumping process for crude oil, which is expected to greatly reduce the cost and difficulty of pumping long distances, says the *Railroad Gazette*. A special 8-inch pipe line 31 miles long has been laid from Volcan Siding in the Kern river oil fields to Delano, Cal., and a pumping plant consisting of three 200 H. P. boilers and a Dow compound duplex steam pump with a capacity of 1,000 gallons of oil a minute, has been installed at Volcan.

The pipe line is laid with 8-inch standard pipe made by the National Tube Co., corrugated on the inside with six grooves, each 3-64 inch deep and ½ inch wide, each groove making two complete turns in a 20-foot length of pipe. The pipe is corrugated by a special process developed by Mr. J. D. Isaacs, assistant engineer maintenance of way, Southern Pacific Co. A plant for corrugating the pipe has been built near Bakersfield, Cal., on the side of a hill, and the pipe is rolled by gravity through the various processes from the time it is unloaded from the cars until it is loaded on cars again. The corrugating machine makes the pipes somewhat polygonal in shape and careful tests are made to discover any defects. Each length of pipe is tested with 1,200 pounds of water pressure, both before and after corrugating. This testing is done by the Pittsburg Testing Laboratory and Robert W. Hunt & Co., and only selected lengths are used. Each length is weighed and measured and a separate record is kept of it.

In operation water is pumped into the pipe with the oil in sufficient quantities to form a shell around the oil which does not come in contact with the surface of the pipe. The grooves cause the water and oil to advance through the pipe with a rotary motion, and it is claimed that with this process oil can be pumped as easily as water. At the outlet a centrifugal separator removes the water from the oil. The pipe line is laid with depressions or traps every 400 feet. These traps prevent the pipe from running entirely dry, in case the pumping stops, and assist in getting the stream of oil surrounded with water under way again. If the tests to be made prove the new system to be successful it will probably be adopted on a large scale on the Pacific coast.

[It will be understood from the foregoing description that this ingenious scheme, which endeavors to make a complete concentric film of water around the body of oil, does it by means of "rifling" grooves which cause the whole mass to rotate, which action is expected to prevent the water from collecting at the bottom as it otherwise would do. The outcome of the scheme will be awaited with much interest.—EDITOR.]

## THE COMMERCIAL PUMPING ENGINE.

*Paper presented by Chas. A. Hague before the Twenty-fifth Annual Convention of the American Water Works Association.*

In this paper Mr. Hague, the well-known consulting engineer of New York, enters fully into the subjects of specifications for the design and construction of pumping engines and also discusses the economic performance of such engines. In what follows are extracts from the address, which include some of the important points brought out.

Some of the first things needed to be known by the builders of pumping engines are the conditions of service under which the engine is to operate. These can be conveniently made known by stating the number of gallons required to be pumped per 24 hours, giving the total water load upon plungers, including fricton of suction and delivery mains, static head, point and manner of delivery of the water, and making this statement in a positive manner, releasing the engine builder completely from all responsibility for the details making up the total load, but requiring of him an engine capable of delivering the given quantity of water against the aggregate working pressure under the stated conditions.

The methods of determining the capacity of the main pumps vary according to the ideas of the builders and buyers; sometimes a weir only; sometimes a weir in conjunction with the plunger displacement. The writer has reached the conclusion that with proper pump construction, the plunger displacement is adequate and conclusive, care being taken that the pump valves are reasonably and practically tight under pressure and of a design, including their seats, which will place their capa-

bility of holding water beyond doubt. When it is realized how much work and carefulness is necessary in constructing and arranging a suitable weir, the clean cut, unmistakable performance of multiplying the actual areas of the plungers easily measured, by the length of the stroke also easily and accurately determined, will be found to be much preferable; especially so when it is considered that an excess allowance of say five per cent in plunger area can be provided to make up for possible deficiency at the stated speed of travel, so as to insure the actual quantity called for.

The area of pump valve openings is a subject which has led to many arguments and disputes during the development of pumping machinery, the reference often being to percentage of plunger area in denoting the aggregate "valve area" of the pump. But the valve area by itself, that is, the number of square inches of opening through the valve seats, will not answer the question in relation to the plunger area. The valve area is a factor of the quantity and really independent of the incidental area of the plunger, and as a matter of fact the flow of water through the valve seats must not go above a certain velocity if the proper relation of the pump is to be retained. It matters not whether we consider a small plunger at a high rate of travel or a large plunger at a slow rate of movement, which means that as long as the quantity of water flowing per minute and the valve area remain constant the changing of the plunger will matter but little. If we talk about the valve area in terms of the percentage of the plunger area, the speed of the plunger must be considered, and this has led the writer to adopt a rule to govern in such cases, which is to divide the feet traveled by the plunger per minute by two and let the result represent the percentage of the plunger area for the valve seat openings. For example:

| Piunger Speed per minute in feet. | Percentage of Plunger Area in the Valve Seats. |
|---|---|
| 100 feet. | 50 per cent. |
| 150 | 75 |
| 200 | 100 |
| 250 | 125 |
| 300 | 150 |

The moving parts of a pumping engine should have strength and stiffness to avoid tremor and vibration while at work; the steam pistons should be light and strong with liberal bearing surfaces, and self adjusting packing; the latter day requirements calling for polished faces both for the pistons and the inner surfaces of the steam cylinder heads to reduce the radiation to the lowest possible limits. The piston rods are made and attached in various ways and of slightly different material, but the most favored probably are of forged open hearth steel with about four-tenths per cent carbon, highly finished all over and not draw filed. They are attached to the pistons sometimes by forcing and sometimes not; generally in large engines secured by a nut or key. Builders of good repute follow slightly different methods but they all seem to arrive at satisfactory results. The piston rod is a beautifully simple detail, but it can be made badly at times even at considerable expense. The piston rod packing is generally in these days of high and dry steam, of the semi-self-adjustable metallic construction; the perfectly cylindrical parallel form of the rod coupled with high polish and finish, when such is obtained, going a long way toward the long wear and good service of the metallic packing; in fact it pays a large profit to the buyer to have some money spent upon the character of the piston rod.

### Specifications for Materials.

In the better practice forged steel cross heads are used where practicable or appropriate; having the piston rods a close fit in the sockets and secured by means of forged steel nuts of extra depth in proportion to diameter. Cast steel cross heads are also successfully used where a competent metal properly annealed may be obtained.

In crank and fly-wheel pumping engines the economical production of the very highest quality of solid open-hearth steel forgings, and center forged steel details for steam machinery is gradually bringing the grade of various parts of pumping engines up to the highest known levels for such work. Although costing a small percentage more than wrought iron, the very best and really cheapest material for piston rods, connecting rods, crank shafts, cranks, distance rods, and other details of like nature is steel, forged under hydraulic pressure from clean, sound ingots somewhat larger in mass than the finished product, and the piece properly annealed. Such forgings not infrequently have a tensile strength of over 80,000 pounds, and an elastic limit of 50,000 pounds, with an elongation of 25 per cent before parting under test.

Among the points to be mentioned in the specifications are the following: The iron castings should be free from blow holes, flaws, cold shuts, blisters, and defects of any and all descriptions. Soft spots left by core chaplets to be completely remedied and obviated if occurring; and the buyer of the machinery should have the right to reject any and all castings not thoroughly sound and which may be discovered to be fractured or otherwise damaged or defective after the engine is erected. The castings should be smooth and true to form, sound, of tough, strong material and of proportionate dimensions.

The cast iron used in the steam cylinders, steam distribution valves, and the pump plungers should be close and fine grained, hard as can be practicably worked, uniform, and with good wearing qualities.

The framing, flywheels where used, pump bodies, and other fixed parts should be of a first class machinery mixture, possessing a tensile strength of at least 20,000 pounds per square inch.

If there are any steel castings used in the construction, they should be thoroughly annealed, and have a tensile strength of not less than 60,000 pounds per square inch and not more than 65,000 pounds per square inch; and have an elongation of 15 per cent before parting.

All steel forgings used in the construction should have a tensile strength of not less than 75,000 pounds per square inch, an elastic limit of not less than 35,000 pounds per square inch, an elongation of not less than 25 per cent, and a reduction of area of not less than 35 per cent, all of the above mentioned requirements based upon standard samples and methods.

All wrought iron used in the construction should be tough and uniform in character; and specimens broken in a testing machine should show a tensile strength of at least 55,000 pounds per square inch, and an elongation of 15 per cent in eight diameters.

All rods should be formed, whether rolled or forged, in one homogeneous continuous piece without weld. Any evidence of a weld in such pieces should subject same to rejection from the work.

The composition metal used should consist of the best quality of new material only, of a mixture or mixtures specially adapted to the particular work in each case.

The babbitt metal used should be of a quality which will show upon analysis to be that required with reference to the percentage of pure tin, percentage of antimony, and percentage of copper; and the buyers should have the right to have such analysis made whenever desired, but at the buyer's expense.

All rivets used, if any, should be made of the best refined iron, and should be capable of being bent cold until the sides are in close contact without any signs of fracture at the convex side.

### Duty and Economy of Pumping Engines.

During the past twenty-five years there has probably been nothing concerning the capabilities of pumping machinery so much and variously discussed as its economic duty; or, the ability or inability to develop more or less foot pounds of work upon one basis or another of comparison, mostly per thousand pounds of steam consumed, or per million heat units utilized. Twenty-five years ago 60,000,000 foot pounds duty was a general guarantee for water works engines, with occasionally an engine of special design aiming to show 100,000,000 foot pounds, the advocates of the higher type and more costly machine arguing that the saving in fuel represented by the greater economy would more than pay the interest upon the difference in cost of the machinery. This saving was a fact, upon the showing of the returns provided the engines were equal in other respects, principally as to the ability of the machine to successfully and continually pump water without unusual interruption on account of stoppage and break down and needed repair. Years ago, the writer took the ground that the

first duty of a pumping engine is to pump water and sees no reason to change that idea to-day; but in the early days of higher duty than about 60,000,000 foot pounds, the engines were not built as a rule quite so sturdy for the hard work of pumping as their lower duty competitors, and if durability, smoothness of operation, and decreased cost, had not gradually forged to the front, in the construction of pumping machinery for water works, the present admirable results would not have been attained and reached so high a level as at present.

In large engines, and under good boiler conditions, yearly duties are maintained as high as from 120,000,000 to 135,000,000 foot pounds per 100 pounds of coal burned; and, of course, it must be borne in mind that no matter how high a steam efficiency a pumping engine may show, the results at the boilers in producing the steam have a controlling influence upon the yearly reports upon economical operation.

For example, with a pumping engine giving an indicated horse power with the consumption of 12 pounds of steam per hour, the actual duty in coal consumed would be as follows:

With 8 lbs. evaporation in the boilers, 120,000,000 duty.
With 8½ lbs. evaporation in the boilers, 130,000,000 duty.
With 9 lbs. evaporation in the boilers, 135,000,000 duty.

The complaint has often been made that pumping engines do not give so high a duty in regular service as upon the test with experts. In general terms this must be admitted and because the experts know how to adjust the engine and operate it to comply with the conditions found to exist, better than the attendant usually found in pumping stations; and this difference in operation in favor of expert work is because the expert by his more extended knowledge of the subject is a more valuable and a higher paid man than the regular attendant as a rule. But it would not pay for all the difference in economy to employ scientific experts to operate a pumping station, although for purposes of contract comparisons the very best work of the engine is sought to be brought out by the contractor, and this is just what the expert does, leaving it to the regular attendant to approximate as nearly as possible under every day conditions and multitudinous cares, the pace set at the regular test.

The adaptation of a pumping engine to its conditions so far as may be, is the key to highest efficiency under the conditions imposed. There are advocates of high speed, of high steam pressure, of high rate of revolution, and other singled out and isolated factors, but the general combination wherein the machine best meets the conditions is what will yield the best results, and not the exploiting of any particular seemingly important factor by itself. And, as an example of this fact it may be noted that the pumping engine which holds the high duty record in this country, if not in the world, has the following conditions to work under:

Capacity per 24 hours, 15,000,000 U. S. gallons.
Piston speed, 197 feet per minute.
Rotative speed, 20 revolutions per minute.
Water load against pumps, 126 lbs. pressure.
Steam pressure per gage, 126 lbs. pressure.
Indicated power, 802 horse power.
Mechanical efficiency, 96 per cent.
Steam per hour I. H. P., 10.68 pounds.
Duty per 1,000 lbs. steam, 179,454,250 foot pounds.

Regarding high piston speed, the best record known to the writer as to pumping engines is 607 feet per minute, where the duty per 1,000 pounds of steam was 157,843,000 foot pounds, showing that higher piston speed alone will not answer.

Regarding high steam pressure the record seems to be 200 pounds and a duty of 149,500,000 foot pounds, showing that high steam pressure in the absence of other ruling conditions or proper fitness falls short of the best performance.

Regarding thermal efficiency, or the actual economy of heat employed with reference to absolute temperatures, even the greatest thermal efficiency does not in the presence of adverse conditions in some other direction, equal the engine working under the best general fitness of things as will be seen by the following:

| Thermal Efficiency. | Duty per 1000 lbs. Steam. |
|---|---|
| 22.8 per cent. | 149,500,000 foot pounds. |
| 21.63 per cent. | 178,497,000 foot pounds. |
| 21. per cent. | 179,454,250 foot pounds. |
| 20.85 per cent. | 173,620,000 foot pounds. |
| 20.78 per cent. | 176,419,600 foot pounds. |

What is considered the record for general all round efficiency for a pumping engine up-to-date is as follows:

Capacity per 24 hours, 30,000,000 U. S. gallons.
Steam pressure gage, 185 lbs. per square inch.
Piston speed, 195 feet per minute.
Duty per 1,000 lbs. steam, 178,497,000 foot pounds.
Duty per million heat units, 163,925,300 foot pounds.
Steam per hour, I. H. P., 10,335 pounds.
Thermal efficiency, 21.63 per cent.

With reference to the steam economy of the higher type of pumping engines and its repetition in different engines it may be noted that covering a period of more than three years, five pumping engines of a similar type, of different builders, and situated many miles apart, gave steam per indicated horse power ranging through the following figures:

10.33 pounds per indicated horse power per hour.
10.63 pounds per indicated horse power per hour.
10.78 pounds per indicated horse power per hour.
11.01 pounds per indicated horse power per hour.
11.10 pounds per indicated horse power per hour.

It hardly seems probable that materially higher efficiencies will be obtained in the near future at least, and not very much higher efficiency is possible with the steam pressures seemingly practicable to employ in pumping stations; super-heat in the steam will no doubt carry the record to slightly higher figures, perhaps to 200,000,000 of foot pounds or a trifle higher, as the reheating and superheating of the receiver steam by means of coils in the boiler connections or smoke flues will also tend in the same direction, but, of course, net gain is what is sought, and fancy duty figures at the expense of heat in some other part of the plant will not add to real economy in the long run.

---

## THE SAFEGUARDING OF LIFE IN THEATERS.

In our last issue we made some reference to the paper read by President John R. Freeman of the American Society of Mechanical Engineers at the opening meeting. This paper, containing as it does the results of an extended series of experiments and investigations by a specialist of wide reputation, carries with it a considerable degree of authority, and the data presented and the suggestions made are therefore especially worthy of being put on record. The following is an abstract of this paper covering some of the chief points of interest.

The direct cause of the great loss of life in the theater disasters which have taken place in various cities at various times has been the outburst of flames and poisonous gases from the combustion on a stage crowded with scenery. The opening of a door in the rear of the stage, bringing an inrush of air, combined with the absence of suitable smoke vents over the stage, together cause an outburst of smoke from beneath the proscenium arch, and result in death by burning and suffocation to the spectators in the crowded gallery. There have been at least four great disasters of this kind, all of them of sickening proportions, and all of them caused by practically the same chain of circumstances. In 1876 at Conway's Theater in Brooklyn the scenery was set on fire and, by the opening of large doors in the rear of the stage, a blast of suffocating smoke was produced, killing about 300, all of whom were in the upper gallery. At the fire in Exeter, England, within five minutes 200 were killed, mostly in the upper gallery. In 1881 at the Ring Theater in Vienna with an audience of about 1,800 a large door in the rear of the stage was opened the minute the fire was discovered, letting in a blast of air that sent the flame through the proscenium arch. The iron curtain could not be lowered, special exit doors were found locked, and 450 were killed, mostly in the gallery. The Iroquois disaster in Chicago is too recent and well-known to require a detailed description.

The problem of protecting the audience in a theater from the effects of a fire on the stage is not one that requires any new knowledge or any investigation along lines not already understood by engineers. After the Vienna disaster a committee of the Austrian Society of Engineers was appointed to investigate this matter and the results of their investigations have been on record for a great many years. The main problem is to give prompt and certain vent to the smoke and suffocating gases elsewhere than through the proscenium arch.

The construction of the stage, arch, and scenery loft in a modern playhouse, as may be seen by looking at a cross section of any such structure, bears a remarkable resemblance to that which would be presented by taking a section through an ordinary open fire-place. The conditions would thus seem to be exceedingly favorable for creating a draft from the audience toward the stage, instead of in the contrary direction, providing an outlet is made at the top of the chimney-like loft for an escape for the hot gases. There seems to be some recognition of this fact in the minds of the men who framed the various regulations applying to theater construction in the various cities. For instance, the building law in the city of New York reads as follows: "There shall be provided over the stage metal sky-lights of a combined area of at least one-eighth of the stage, fitted with sliding sash and glazed with double thick sheet glass, . . . the whole of which skylight will be so constructed as to open instantly on the cutting or burning of a hempen cord. . . . Immediately underneath the glass skylight there shall be wire netting, etc., etc." The ratio of smoke vent area to stage area given in this extract from the building laws is about that usually used in proportioning the area of the chimney and fire-place opening and agrees very well with the Vienna experiments and the practice which has been found desirable in England and other places where this matter has received attention. There are, however, a few almost criminally dangerous points about this New York law. The evident purpose of the thin glass is to cover the opening with something that will break out under heat if the mechanism for sliding off the cover fails. The wire netting is to prevent any pieces of broken glass from falling to the stage. This requirement as to the glass is well meant but it would be too slow in breaking out. Unconsciousness and suffocation come very quickly in an atmosphere of smoke. The wire netting is a positive danger as often applied. The Austrian experiments demonstrated that the force of the upward draft caused by the fire on the opening of the smoke vents, carries with it large pieces of flying scenery and other debris which lodge against the screen and almost entirely close the opening. This provision is one that should be changed at once. On Pres. Freeman's visit to the remodeled Iroquois he found the opening in their new vent shaft screened in a way that would, possibly in a minute's time, put them into a condition of uselessness.

Another dangerous provision is the use of a hempen cord instead of a fusible link for holding the skylight closed. There is no good reason to expect that a hempen cord in this position, in smoking atmosphere from which the oxygen has been largely removed, will burn off until a majority of those in the gallery have been suffocated. Fusible links have been in common use on automatic fire shutters in factories for nearly twenty years. It is almost beyond belief how slowly and scantily these have found their way into the fire protection of theaters.

Not only are the laws relating to this subject badly framed but they have in many cases been executed with a carelessness that is really criminal. In one of the newest and best theaters of New York the speaker found the ventilator with a broad sheet of heavy canvas laced tightly across its opening with marline. As the stage carpenter remarked, the cracks around the ventilator let in too much cold air. No building inspector had objected and the carpenter could not be made to see any danger. "It would burn off in any bad fire," he stated. So it may, but not until those in the gallery are mostly dead.

Concerning the design of smoke vents, there are practically none in actual use which have been designed intelligently and with a full consideration of the importance of details. The fundamental requirements are: Absolute certainty of opening by force of gravity in spite of neglect, rust, dirt, frost, snow or expansion by heat, twisting or warping of frame work. Quickness of opening to be secured by automatic links of improved design and by hand control from the prompter's stand and the station of the stage fire guard. The operative mechanism should be simple and massive, built more like rolling mill machinery than in accordance with watchmaker's practice. The poise weights should give a constant tension of 25 pounds or more on the release cord. The vent should be of such form that it can be tested daily by partially opening it and closing it again, preferably by means of the cord running to the prompter's stand. It should not be so loosely fitting as to let in cold drafts to tempt the stage hands to fill up the opening beneath it. Mr. Freeman presented designs for two types of ventilators, one with hinged shutters, the other with sliding shutters, both designed to meet the requirements outlined above.

The second requirement that should be introduced is the use of a well designed and freely acting fireproof curtain. Most theaters outside of Chicago at the present time are furnished with a fire curtain made from heavy canvas woven from asbestos fiber. For some time after the Iroquois fire there was some doubt as to whether the curtain in that theater was really made of asbestos, as its owners claimed. It fell as mere rubbish to the stage and outwardly little resembled the material of which it was supposed to be made. This curtain was an utter failure in three different ways. It could not be lowered, and stuck fast after passing a distance variously estimated at from one-fourth to one-half the height of the arch. The curtain was improperly hung, being supported at the top in part by being clamped between thin strips of pine wood about four inches wide by three-fourth high. These asbestos curtains in many theaters to-day are hung from a batten of white pine to which they are nailed across the top. When subjected to actual fire the Iroquois asbestos curtain lost its strength and fibrous quality almost completely and became so brittle that it was incapable of standing the pressure of a strong draft of air and was too weak to hang under its own weight.

This last defect is the serious defect of asbestos as a material for a fireproof curtain. Through various channels Mr. Freeman obtained samples from three feet to six feet square from all prominent American manufacturers of theater curtains and asbestos cloth. He also cabled to London and had a competent architect collect samples of asbestos curtain cloth from leading manufacturers and dealers, with instructions to use every effort to procure canvas woven from French or Italian, or other than Canadian fiber. When hard pressed for the pedigree of their samples none of these makers would furnish the canvas under a guarantee that it was made from anything other than the Canadian fiber, and the chemical analysis confirmed the belief that this was the only material used.

There are two or three minerals which go under the name of asbestos. The Canadian fiber is chrysotile. This is the common asbestos of commerce and possesses in a greater degree than the others the properties required for spinning and weaving. Themolite and a third material called anthophyllite, of which no great quantity has been found, are obtained from Georgia, Siberia, and South Africa. They resist heat to a very much greater degree than the Canadian fiber, which loses its strength at about 660 degrees Centigrade, but they are for the most part too brittle for spinning.

Three series of tests were made to determine the fitness of asbestos as a material for a fireproof curtain. The first of these was undertaken by Prof. Fuller, of the Massachusetts Institute of Technology, and was made with a degree of attention to details which renders the conclusions arrived at of very great importance. It was found that every one of these specimens of asbestos canvas, English and American alike, when heated from two to five minutes a little below redness in a common gas flame, or barely to redness in the Bunsen flame, lost 60 to 90 per cent of their strength and the fiber became very brittle. The samples which had interwoven brass wires were no stronger than the other samples, and on cooling they regained little of the strength due to the wire.

A second series of tests was made at the Underwriter's laboratory in Chicago on curtains about 6 feet square. On account of defects in the furnace this test was inconclusive. In the third series of tests Professors Crosby and Warren, of the Massachusetts Institute of Technology, made an exhaustive search through the extensive cabinets of the Institute and of the Boston Society of Natural History in the hope of finding specimens from some locality that possessed all the qualities commonly attributed to asbestos. The result of this search, in brief, was that nothing was found possessing characteristics materially different from the hydrous Canadian fiber on the

one hand, and the anhydrous fiber from Georgia on the other. Those of the first class lost their strength at a heat which drove the water off; the second class were too stiff or brittle to allow their use in a fabric.

In the Chicago tests there were tried different combinations of asbestos, asbestos felt, asbestic cement with thin steel plates and combined with wire netting, the asbestos being placed on the stage side in the hope that it might shield the steel plate curtain from the action of the fire and thus prevent the heating of the steel to redness and the consequent disturbance of the audience. It is plain to all who witnessed these tests that the steel curtain protected with some asbestos material on the fire side possessed far greater strength and endurance against fire than the simple asbestos. The general type of steel proscenium curtain finally adopted in Chicago and required at all theaters, was worked out somewhat hurriedly. The curtain with the framework for supporting it weighs from two to six tons. The handling would be improved by more substantial iron channnels to hold the edge, and by the addition of positive down-haul tackle or some arrangement by which the weight could be thrown off, for now the great weight of these curtains is so nearly counterpoised that conceivably the air pressure against this surface of about 1,000 square feet might prevent the slight excess of gravity from lowering it.

The question of fireproofing scenery was also investigated and in this matter also extensivé tests were made by men thoroughly competent in the matter, and consultations were held with several experienced scenic artists, and the conclusion arrived at was that the best possible in this line is far from satisfactory. The petty tests that have long satisfied several distinguished chemists are very misleading as guides as to what may happen on a larger practical scale, and the best we can hope to accomplish is to flame-proof a fabric so that it will not ignite from a match or electric spark or a gas jet, or so that, if ignited, it will not burst into flame. After investigating this question Mr. Freeman is of the opinion that we must after all rely on the safeguards of the engineer rather than those of the chemist. Disappointing conclusions resulted also from the investigations into fireproof woods and fireproof paints.

Perhaps the most interesting of all the experimental results recorded in this paper are those which relate to the composition of the chemicals contained in the various dry-powder and liquid fire extinguishers on the market. It is scarcely necessary to do more than call attention to the accompanying tables, which are compiled from the results of analyses made by reputable chemists on all the different varieties of extinguishers that could be found in the open market in and about New York. It will be noticed that the composition sold under the name of "Kilfyre," of which there were several tubes on and about the stage of the Iroquois, is composed almost entirely of bi-carbonate of soda or "salaratus," as the cook calls it. This, in the form and quantity in which it is found in the tubes, could be bought for about 10 cents; the extinguishers are sold at retail for as high as $3.00 apiece. Practically all these dry extinguishers are composed of common bi-carbonate of soda, frequently disguised by the mixture of cheap coloring matter like Venetian red. Possibly this material has some small value for a certain class of fires. Doubtless it is wise to carry a few tubes of this on an automobile. Doubtless in confined situations the bi-carbonate powder may sometimes do remarkably well, but it should never be used to give a full sense of security about the stage of a theater. Underwriters do not accept it in factory fire protection. They recommend that it be thrown into the rubbish heap. Pails of water are far more reliable. In general the materials of which all these extinguishers are composed render them of doubtful value on the smallest fire and entirely worthless for a fire with full ventilation. On the other hand, soda-water fire extinguishers consisting of a copper cylinder containing two, three or four gallons of a strong solution of bi-carbonate of soda, with a bottle of acid at the top so arranged that it can be upset into the soda and water, there-

ANALYSES OF THE CONTENTS OF HAND GRENADES.

| | |
|---|---|
| Hayward Hand Grenade: | |
| Common salt | 22.3% |
| Other solids | 0.4% |
| Total | 22.7% |
| Harden Hand Grenade: | |
| Common salt | 18.5% |
| Salammoniac | 6.7% |
| Total | 25.2% |
| Babcock Hand Grenade: | |
| Common salt | 21.2% |
| Chloride of Calcium | 6.5% |
| Total | 27.7% |

TABLE SHOWING RESULTS OF ANALYSES OF DRY POWDER FIRE EXTINGUISHERS.

| | | Per cents of Chemicals by Weight. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Price. | Name of Extinguisher. | Bi-carb. Soda. | Red Ocher. | Yellow Ocher (or Iron Ore). | Fuller's Earth. | Common Salt. | Amm. Carb. | Sodium Phosphate. | Nitrate Soda. | Charcoal. | Fire Clay. | Sodium Sulphate. |
| | "Kilfyre" | 97.5 | 2.5 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| $3.00 | " | 96.0 | 4.0 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 3.00 | "Kingfyre" | 97.4 | 2.6 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 3.00 | Fyncide | 99.5 | 0.5 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| | "Fore Dust" | 94.8 | ... | 5.2 | .... | .... | .... | .... | .... | .... | .... | .... |
| 3.00 | "Improved" | 87.6 | ... | 12.4 | ... | .... | .... | .... | .... | .. | .... | .... |
| 3.00 | Atomized | 95.0 | ... | 5.0 | .... | .... | .... | .... | .... | .... | .... | .... |
| 0.75 | Driggs | 89.5 | ... | ... | 10.5 | .... | .... | .... | .... | .... | .... | .... |
| 3.00 | Pan-American | 30.6 | ... | 37.9 | .... | 7.4 | 2.3 | 8.1 | .... | .... | .... | 12.9 |
| 3.00 | Phenix | 81.2 | ... | 4.0 | .... | .... | .... | .... | .... | ... | 14.8 | .... |
| 3.00 | " | 82.1 | ... | 17.9 | .... | .... | .... | .... | .... | .... | .... | .... |
| 3.00 | Manville | 95.5 | ... | 1.2 | .... | .... | .... | .... | .... | 2.6 | 0.7 | .... |
| 3.00 | " | 96.0 | ... | 4.0 | .... | .... | .... | .... | .... | .... | .... | .... |

Another series of analyses ran as follows:

| | | $Na_2O$ | $CO_2$ | | | Na Cl | $NH_3$ | | | | | $Na_2So_4$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Soda. | Carb. Acid. | Insol. Matter (Iron Ore). | Water in Bi-carb. by diff. | Common Salt. | Ammonia. | | | | | Sodium Sulphate. | Starch. |
| $2.50 | Kilfyre | 35.4 | 50.6 | 4.0 | 10.0 | .... | .... | .... | .... | .... | .... | .... | .... |
| .... | Monarch | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 3.00 | Pan-American | 15.3 | 20.3 | 41.1 | 14.1 | 6.7 | 0.4 | .... | .... | .... | .... | 2.0 | .... |
| 1.00 | Eclipse | 32.6 | 43.2 | 3.4 | 12.0 | .... | .... | .... | .... | .... | .... | .... | 8.8 |
| 2.00 | Manville | 35.0 | 48.0 | 4.0 | 13.0 | .... | ... | .... | .... | ... | .... | ... | .... |
| 3.00 | Phenix | 30.1 | 41.8 | 17.8 | 10.1 | .... | .... | .... | .... | .... | .... | .... | .... |

Another series:

| | | Bi-carb Soda. | Mono-carb. Soda. | Iron Oxide. | Insol. Dust. | Loss at Red Heat. | Amm. Carb. | Common Salt. | Sodium Sulphate. | Insol. Iron Ore. | Water, etc. | Starch. | Clay. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ..... | Monarch | 93.7 | 2.4 | 3.8 | .... | 35.7% | .... | .... | .... | .... | .... | .... | .... |
| ..... | Fyricide | 94.7 | 4.6 | 0.7 | .... | 36.8% | .... | .... | .... | .... | .... | .... | .. |
| ..... | Pan-American | 34.5 | 4.4 | .... | .... | .... | 1.1 | 6.7 | 2.0 | 41.1 | 10.2 | .... | .... |
| ..... | Eclipse | 87.9 | .... | .... | .... | .... | .... | .... | .... | .... | .... | 8.8 | 3.3 |
| ..... | Kilfyre | 96.5 | .... | .... | 3.5 | .... | .... | .... | .... | .... | .... | .... | .... |
| ..... | Swan | 97.2 | 1.7 | .... | 1.0 | .... | .... | .... | .... | .... | .... | .... | .... |

by generating a strong pressure by the evolution of carbonic acid gas, are excellent for many places where pails would be unsightly.

The accompanying table containing the analysis for the contents of three makes of hand grenades purchased in the open market is fully as interesting as the one relating to the dry powder. The materials are inert and their only advantage over plain water is that they do not freeze at ordinary winter temperatures.

After everything possible has been done to prevent the starting of a fire in a playhouse and to keep it within the bounds of the stage after it has been started, there still remains the exceedingly important question of furnishing a safe and free means of escape to the audience, above all to those in the upper galleries. A type of fire escape has been developed under the building laws of Philadelphia, primarily for use in factories, which is so remarkably efficient and so far ahead in point of safety of anything that exists elsewhere, that it is a wonder it has not been copied in other cities. It is somewhat expensive, but the safety it gives is well worth the extra cost. The fundamental idea is that the stairway proper shall be absolutely cut off from the various rooms and floors which it serves. One must go out from the room into the open air and then enter the stairway. Once within this he can proceed without danger to the bottom. The total number of stairway exits and the total width of the stairway per hundred persons should be two or three times as great for the gallery as for the other parts of the house, and all exits should run in such a direct and obvious course that a person once in them could not fail to find his way to the bottom, even in total darkness. A sad loss of many lives occurred in the Iroquois by reason of a blind passage way from the gallery which led nowhere in particular, but extended out from the main exits in such a way that those rushing downward naturally took it as the line of escape, and a mass of women and children were caught in this *cul de sac* and doomed to suffocation.

## THE TURBINE-DRIVEN CUNARD LINER.

*Abstracts from Article in London Engineering,* Dec 1, 1905.

The *Carmania* was built and equipped by Messrs. John Brown & Co., Ltd., Clydebank. This vessel is one of the seven or eight largest of the world's ships, having the following dimensions: length between perpendiculars, 650 feet; length over all, 672 feet, 6 inches; breadth, moulded, 72 feet; depth, moulded, 52 feet; gross register tonnage, 19,524 tons; draft, in working condition, 33 feet, 3¼ inches; displacement at this draft, 30,918 tons. She was designed for a speed of 19 knots.

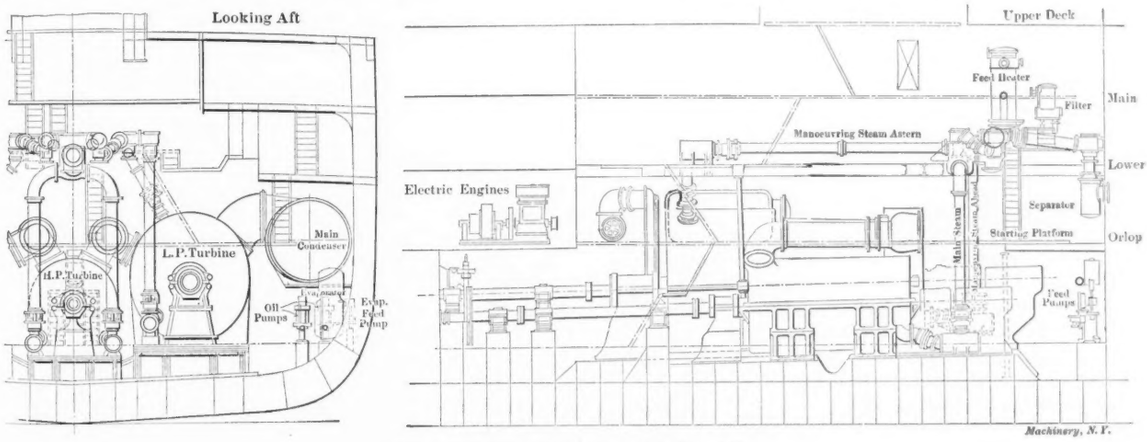



Fig. 1. Elevation of Turbines of the Carmania.

The chief interest in the *Carmania,* of course, centers in her engines which are turbines of the Parsons type, arranged in the usual manner with the high-pressure turbine on the center screw shaft and with one low-pressure turbine on each of the outside shafts. The area occupied by the turbine and auxiliaries is practically the same as required for the quadruple-expansion reciprocating engines of the sistership *Coronia,* built some time previously. The head room is less, however. The arrangement of the turbines and auxiliaries is shown in Figs. 1 and 2. There is a saving in weight by the adoption of the turbine system of about 5 per cent. The boiler pressure in the *Coronia* is 210 pounds, and in the *Carmania* 195 pounds per square inch. The turbines take steam at an initial pressure of about 150 pounds as against 200 pounds in quadruple expansion engines. Another feature in the comparison which may be mentioned is that owing to the high vacuum desirable in the turbine system to insure the fullest economy the cooling surface of the condenser is increased in the *Carmania* about 20 per cent while the capacity of the centrifugal pumps is about double, so that the amount of circulating water discharged is from 50 to 60 times the weight of feed water, as compared with a ratio of 25 to 30 times in the *Coronia's* installation.

It was decided as a preliminary to the design and construction of the *Carmania's* machinery to make a set of three-screw marine turbines capable of developing about 1,800 horse power to be erected on land for experimental purposes. They were fitted with powerful dynamometers and with means for measuring the end thrust which in actual working conditions is balanced by the thrust of the propellers. Exhaustive trials were conducted under all possible conditions, the steam consumption measured, the relation of the ahead and astern turbines determined, etc. Finally, the turbines of the *Carmania* were designed with their proportions based upon the results of these experiments.

A striking feature of the turbines as erected in the engine room of the vessel is the lifting arrangement provided for removing the top half of the casing of each unit for examination of the blades. There are vertical screws for this purpose located permanently and driven by motors. These screws rotate in nuts bolted to the casing. The whole arrangement is a permanent and well constructed detail of equipment.

In normal working conditions the regulating valves admit steam to the high-pressure turbine and the steam passes through it to the low-pressure turbines and thence to the condenser. For maneuvering purposes a large, non-return valve, worked by a steam and hydraulic engine controlled from the starting platform, closes the connection between the high-pressure and each low-pressure turbine. This valve will close automatically as soon as a prescribed pressure is obtained in the low-pressure casing. Each of the low-pressure turbines is then manipulated as an independent unit. Special maneuvering valves are fitted to each of the low-pressure and astern turbines which allow of steam being admitted to either the ahead or astern turbines by a single movement of a hand lever. The turbine is fitted with a governor which operates when there is any marked increase in the number of revolutions.

Oil is supplied to the bearings under considerable pressure. It then flows to a cooling tank fitted with copper coils through which water is circulated and after passing through a system of oil filters is again delivered to the bearings.

### The Turbine Glands.

The gland for the shaft passing through the end of the turbine is rendered steam-tight by means of an improved design shown in Fig. 3. In the Parsons marine turbine of smaller sizes the leakage of steam from the high-pressure turbine and the ingress of air into the low-pressure turbine has been pre-

vented by the Parsons ring-and-groove type of gland. This gland consists of a series of grooves turned in the spindles into which bronze rings are fitted, the whole rotating in a truly bored cylindrical gland. When the difference in pressure between the inside of the turbine and the atmosphere is great the side pressure of these rings is very considerable and in order to distribute this pressure as equally as possible an ingenious method is adopted of arranging the rings in several groups and grading the pressure to each group by suitable connections. (Fig. 4.)

The builders realizing that the vacuum obtained depended mainly on the tightness of the low-pressure glands conducted an extensive series of experiments by means of a specially constructed apparatus which enabled dummy glands to be rotated under the same conditions that would obtain in practice.

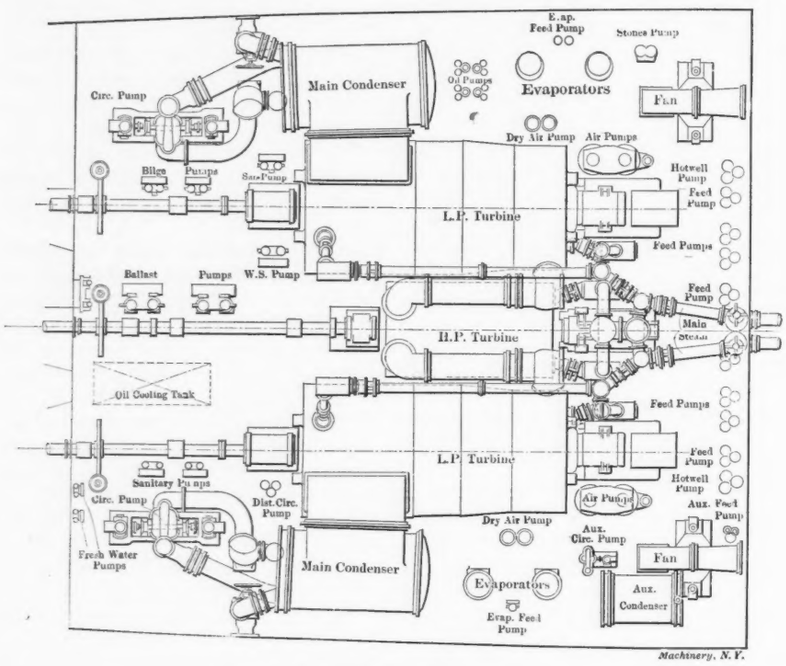
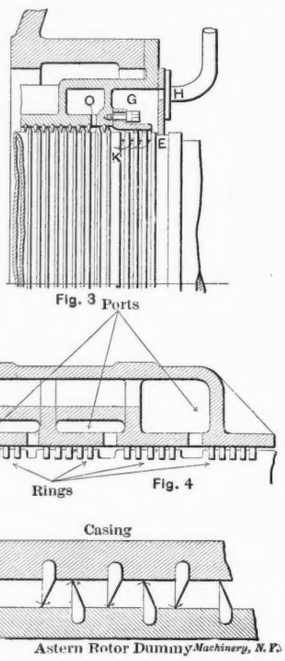



Fig. 2. Plan of Turbines of the Carmania.




Figs. 3 to 5. Gland Packing.

The size of these glands was the same as was to be used in the turbines of the *Carmania*. At first the regular Parsons ring-and-groove type was tried. The diameter of the gland was so large, however, and the speeds were so high that the rings gave unsatisfactory results, wearing rapidly. Examination of the scored surfaces led to the conclusion that the difference in pressure between the successive groups of rings was too great and an introduction of more groups to reduce this pressure would have led to serious complications; but after further experiments it was found that the desired result could be readily obtained by the adoption of radial fins, as shown in Fig. 5. The action of these fins is to alternately wire-draw and expand the steam, each pair constituting an expansion stage, thus reducing its pressure as it travels outward. The actual gland was fitted at each end of both the high- and low-pressure turbines, as illustrated in Fig. 3, with four rings, *K*, at the outer end. The small amount of steam which is allowed to leak past them for the purpose of lubrication collects in pocket *G*, whence it is led by the pipe *H* to the auxiliary condenser or exhaust tank. In the case of the high-pressure turbine, where the radial fins do not sufficiently reduce the pressure of the escaping steam, the pocket *O* is connected to an expansion row in the low-pressure turbine.

It is of the utmost importance in the practical working of a large marine turbine that means should be provided for determining the pressures at different stages of expansion; and what is of more importance, for ascertaining that everything is running satisfactorily inside the casing. To accomplish this a valve box is connected by pipes leading to the several stages of the turbine, each pipe running to a separate chamber in the valve box in which is a valve closed by a spring, but opened by a cam on a shaft that may be rotated by hand. There is a cam on each valve and as the valve is rotated the different cams come into action in succession, opening one valve after the other and admitting steam successively from the different chambers to one large chamber having a steam engine indicator attached. The indicator drum is given motion by a cord wound around a sheave on the shaft and during the rotation of the shaft, therefore, the pencil of the indicator traces a stepped line showing pressures existing in the different stages.

* * *

## THE FEBRUARY DATA SHEET.

The table printed in the data sheet accompanying this issue of MACHINERY gives the number of sixty-fourths contained in all mixed numbers from 1/64 to 17 inclusive, varying by 1/64. Mr. Louis F. Lang, who contributed this table, uses it for adding fractions, as, for instance, when obtaining the over all dimensions of a piece by adding together the detail dimensions. Suppose we desire to make the following addition:

$$2\ 19/64 + 1\ 17/32 + 3\ 11/16 + 7\ 27/64$$

We find the number of sixty-fourths in each of these quantities by locating its integer in the row of heavy figures at the top of the table and then following that column down until it intersects with the horizontal row which contains the required fractional quantity in the left-hand column. Setting down the number given at this intersection for each quantity, and adding them together, we have:

$$147 + 98 + 236 + 475 = 956$$

This gives us the number of sixty-fourths contained in the sum desired. To express the result as an improper fraction we divide it by 64, thus:

$$956 \div 64 = 14\ 60/64 = 14\ 15/16 = \text{Ans.}$$

* * *

The conception of Dalton that an atom is a solid, indestructible, eternal, indivisible portion of matter has been modified by recent discoveries of science to such an extent that it may be regarded as obsolete. The amazing revelations of radioactive elements like radium have made a new conception of the nature of matter imperative. The new idea is that the atom is not necessarily indestructible but may be regarded merely as a sort of motion or a whirlpool in the ether. When this motion stops the atom ceases to exist. But however this may be, it is known that the atom is divisible, the smaller particles composing the atom being known as electrons. It is computed that a hydrogen atom contains about 800 electrons and that they are moving with a velocity of about 200,000 miles a second!

## THE MANIPULATION OF HIGH-SPEED STEELS.

W. J. TODD.

The rapid progress of tool steel manufacture, and particularly the advent of high-speed steel makes it more and more necessary for the successful toolsmith to devote some of his spare time to a careful study of the nature and adaptability of new steels with special reference to their use in tool making. For, unlike the air-hardening steels of a few years ago, the high-speed steels of to-day can be used in innumerable ways for making tools which formerly were made only of carbon steel. The ease with which high-speed steel may be forged, shaped and hardened permits its use in the construction of many tools and dies. Hence, we not only find it in use in the machine shop for cutting tools, but in the press room for the construction of forming dies for hollow ware; also for wire-forming dies, and in the bolt mill for bolt heading dies on hot work. It is used for shearing dies for hot and cold bar work and for many various other purposes unthought of in connection with air-hardening steel. But, unfortunately, owing to the number of different makes of alloy steel now in use no standard rule can be adopted for manipulation. Therefore, in order to determine the proper forging and hardening heats it must be a matter of experiment for the toolsmith and he will find it a very good method to test the particular brand he is about to use by giving a piece of it as much heat as he thinks the steel can properly stand and noting the result.

The writer has found that a majority of the high-speed alloy steels should be heated whenever possible in block fire with a good body of forge coke. Thoroughly heat the steel in a clean bright fire to a full yellow plastic heat, which means a temperature of 1,650 to 1,850 degrees F. This, of course, is a much higher temperature than can safely be used in forging air-hardening or carbon steel. In fact, the heat treatment given alloy steels of the high-speed variety is so diametrically opposite to the generally accepted practice of working carbon steel that it seems to be a difficult matter to persuade the average smith to raise the heat to the proper temperature when working high-speed steels, but when this fact is once impressed, he will be surprised at the ease with which it can be worked. By rapid forging and repeated and thorough heating, it will be found no difficult matter to give alloy steel almost any desired shape, but, unlike carbon steels, it will not do to run the heat down low in forging, as in such practice the steel will most likely be found cracked or split. To heat thoroughly and often is the essential point to remember.

After forging alloy steel for lathe, planer and shaper tools, it is, of course, unnecessary to anneal them other than to let them cool down in the air in a dry place. When cold, rough grind to proper edge and then they are ready for hardening, which process will be described later. In making use of alloy steel for taps, reamers, twist drills, milling cutters, or forming dies, it will be necessary to anneal the forgings in order to enable them to be worked in the machine shop.

The different sizes and shapes of this steel can generally be procured already annealed from the steel maker, but when unable to obtain the annealed bar and the work is required to be annealed, proceed in the following manner: A very successful method of annealing high-speed steel, and also self-hardening steel, consists of placing the tool in a wrought-iron or cast-iron tube, having space large enough in circumference and length to accommodate the work and plenty of packing material. One end of the tube can be threaded for a cast-iron cap, which can be screwed on and off as desired; the other end can be permanently fixed on the tube, as it is generally only necessary to use the one end. Have a number of ⅛-inch holes drilled in the tube, and also a few 3-16-inch holes in the end caps. The idea of the holes in the tube is to act as a vent and let off the gas which is generated from the packing material heating. The end holes can be used for a number of test wires, which can be withdrawn as the heating progresses, and by this means the operator will be able to ascertain the proper heat desired, which should be a bright orange or a trifle higher, according to the nature of the steel. When the desired heat is reached, regulate the blast sufficiently to hold the muffle and its contents at this heat for a period long enough to allow the heat to thoroughly penetrate the steel. Then the muffle with its contents may be buried in dry slaked lime, or sawdust and ashes, and allowed to cool down slowly. If a furnace is used for the heating, allow the muffle to stay in until furnace and all cools down, when the steel will be found quite easy to work in the machine. I would say, though, respecting this "dead heating" in the furnace, that unless the steel is properly packed in the muffle in order to exclude the oxygen blown into the furnace by the blast, the steel is apt to oxidize and the carbon content thereby become lowered, resulting in overannealed steel. The packing material used may be any one of several kinds now commonly used for other work, but charred leather gives the best results, and dry, fine smith coal of a good, clean quality is effective.

Now it is up to the machinist to finish to the desired shape. This he will find will be facilitated by using for a cutting tool a piece of the same steel, hardened. After he has accomplished his part of the work, it is then necessary to have the work hardened, which can be done in numerous ways according to the requirements desired for the tool. For turning and cutting tools for lathe, planer, shaper, and slotter, it will be found a good practice to heat the nose of the tool slowly to a bright red, then bring it rapidly with a good, quick fire to a white fusing heat, about 2,200 degrees F., on the point, then quench it quickly in oil and leave until it is cold. It must be borne in mind, however, that when a tool is at this high fusing heat it must not come in contact with the fuel of the fire, as, should that occur, the nose of the tool would be ruined and necessitate considerable grinding or reforging into shape. After regrinding the tool on a wet stone it will be ready for work and should give a good account of itself, and incidentally reflect credit on the smith who worked it.

The oil used may depend on how hard the tool is desired. We will suppose it is required dead hard on the cutting edges; this is as hard as it is possible to make it for machine shop use and still retain sufficient toughness. To obtain this result, after fusing the point or cutting edge quench quickly in thin lard oil, or for extreme hardness, quench the tool in kerosene oil, when about the limit of hardness in this steel may be obtained. In using oils, especially the kerosene, great care should be used or the oil may flame and burn the operator. The oil tanks used for hardening should be constructed preferably of galvanized iron, fitted with close-fitting covers, and provided with a screen a few inches from the bottom on which to rest the work in order to facilitate the quenching by allowing free circulation of the quenching bath to all parts of the tool.

In hardening machine-finished work, such as dies, milling cutters, taps, etc., made from this steel, we must proceed differently, as the course described would not answer for all purposes. All machine-finished work should be packed in muffles or iron boxes described in annealing, bringing the heat up in a similar manner, testing as also described. When heated sufficiently remove the cover of the muffle and quench the tool in a bath of oil, composed of half parts each of thin lard and raw linseed oils, keeping the tool in motion while in the bath until it has cooled to a little below the boiling point of the oil. Then it can be removed from the bath and left to cool in a warm, dry place, when, after being cleaned and polished, the temper may be drawn to a dark straw for general purposes. I may add that it is not always necessary to draw the temper on this character of tools; neither is it always necessary to harden such tools as milling cutters, dies, reamers, taps and drills in the oil. Very often it will be found only necessary to heat them to a good, bright red heat about 1,500 degrees F. and lay them in a cold blast; when cold they will be hard enough for ordinary work. The objectionable feature of the cold-air blast for such work is the liability of the steel to scale on the finished parts and possibly cause a slight loss in size, though this seldom occurs when proper care is used and the steel is not heated to a scaling point. The cold-air treatment, however, is applicable to work such as forming dies, wire dies and tools required to withstand some shock.

Sometimes it is unnecessary to pack the work as it may be successfully done by just using the tube and closing one end only. Place the tube in the fire and the work in it, bringing it to the required heat with a gentle blast and always keeping

the tube turning to insure an even heat and to prevent it burning.

In all instances the operator must exercise his best judgment in heating and quenching the tool according to its shape and the nature of the service required of it, but care must be exercised in selecting the steel when making tools of the high-speed steels to avoid getting a bar which may be "piped" or which contains "laps" or "cold shuts" formed in the ingot from bad teeming, or caused during the tilting. The density of its structure and the tendency of the alloys to segregate in the ingot makes it a difficult steel to manufacture of a sound and uniform quality. High-speed steel of high-grade quality is, therefore, necessarily high priced, but when the efficiency of its service is considered it is acknowledged the superior to high-carbon steel for every purpose where it can be used.

* * *

## NOVEL BLUE PRINTING APPARATUS.

H. O. GARMAN.

The necessity for having some contrivance to hold a tracing or vandyke negative firmly against the sensitized blueprint paper or cloth, and at the same time to protect from the weather both the operator and his material during the time of exposure of the print, has given rise to many inventions. The different devices range from the simplest common hand frame to the varied and more or less complex blueprinting apparatus of the automatic type, and the price varies from the insignificant cost of the small hand frame on the one extreme, to as much as $500 to $600 for the larger and more complex machines. The cost of labor for printing is nearly inversely proportional to the number of prints that the frame will hold at a single exposure, provided the tracings or negatives are fastened together, the small separate sheet system of printing being very expensive. When several prints are

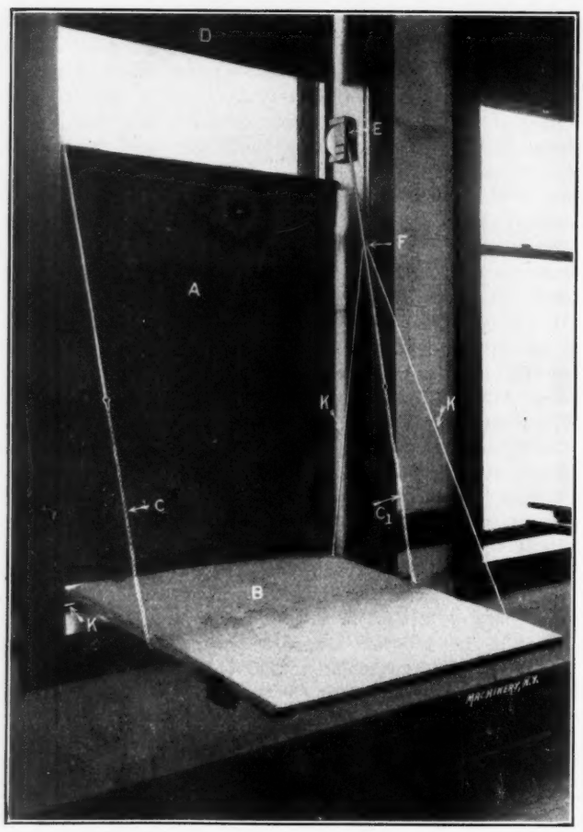



Fig. 1. Novel Blue Printing Frame.

made at one exposure no dark room is necessary, for a large piece of paper can be quickly placed in position, exposed and washed, and then cut apart in the full light at the leisure of the operator or during the time of exposure of another frame.

It is not the purpose of the writer to describe a machine which is better than some of the best machines we now have, but rather to describe a novel device for making both large and small prints, the design and cost of which brings it within the reach of any one having such work to do.

When one is called upon to make only an occasional small print it will be found that a small hand frame exposed directly to the sun's rays is the most economical method; but when the number of prints required increases beyond a certain limit

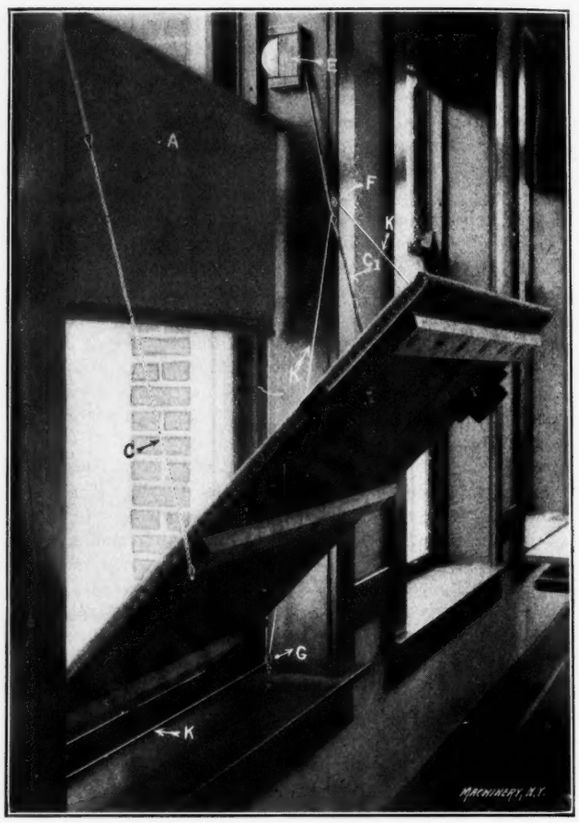



Fig. 2. Raising the Back into Place.

and when the size of prints exceeds say 2 by 3 feet or 3 by 4 feet, the hand frame, if substantially made, becomes very cumbersome. When prints are being made continually, as in a blueprinting establishment, the more complex electric machines are necessary, but in most places where drawings are being made there is not a continual demand for prints so that the cost of one of these machines would be a waste of capital; and too, it is not always convenient to obtain the electric current. In such case one is obliged to resort to the sun as a source of light and to some cheaper means for holding the tracings than is adopted in the special devices. The large hand frame must either be: (1) carried out of doors; (2) run out through an open window on a track; or (3) left lying on a table inside a closed window. The first method is exceedingly tiresome to the operator; the second allows a draft to enter the room and disturb papers, etc., and in winter time may endanger one's health from cold drafts; also the inside track design takes up too much space. Then too, both of these methods during rain storms endanger the tracings and negatives. The third method is expensive in that it demands a longer time of exposure, caused by the sun's rays having to pass through two thicknesses of glass at acute angles.

The blueprint frame to be described in this article is particularly applicable to use in the office of a consulting engineer, contractor, small railway division headquarters, etc. It has served a useful purpose in the blueprinting work done for the school of civil engineering in Purdue University. After considering all the points of economy both in the cost of apparatus and production of prints for such offices as just named (where, as already stated, the sun must generally be used as the source of light) a contrivance for exposing the sensitized paper to the sun should provide for the following features: (1) Minimum time of exposure; (2) protection of the trac-

ings while exposing; (3) ease of placing the prints in frame and exposing same; (4) protection of the operator from the weather; (5) no dark room for cutting paper; (6) least possible encroachment on inside space in office.

The requirements are: (1) A south window; (2) a drawing board the size of the window glass; (3) a supply of heavy table padding and cotton batting; (4) two Pullman spring window counter-balances; (5) an ordinary roller window shade; (6) three hinges; (7) two spring catches; and (8) some strong cord. It is not necessary to purchase a glass of any kind, since the regular window glass is used. See Figs. 1 and 2.

Cut one piece of the table padding large enough to cover the board, with surplus to allow tacking to the side. Cut the remaining piece of padding into four other rectangles, each being made smaller than the preceding. Place the pad rectangles concentrically on the board, then cover uniformly with cotton batting and over this place the largest piece of pad mentioned above, the same being tacked to the sides of the board when well stretched. This gives pyramidal or convex form of cushion which insures a uniform pressure against all parts of the window glass, the elasticity of the glass allowing it to bulge into this form. Experience shows that the window glass should be held in place with screws and wooden strips, putty not being strong enough to permanently stand the pressure. Next, place the padded board in the window and attach the hinges to the lower side of the board and to the bottom sash bar; attach the spring catches on the top sash or on the side sashes near the top. This holds the board firmly in place. The balancing apparatus, consisting of the two Pullman spring counterbalances, are attached one on each window casing about opposite or a few inches above the top sash, the suspenders being attached to the board on each side at such a point between the top end and the hinge as to produce equilibrium. The roller window shade is fastened to the casings about 4 inches above the top end of the board an inch from the sash, and both of its catches removed, making it possible to run up or down without interference. The shade is operated automatically as the board is raised and lowered, thus shutting out the light when the board is horizontal and the sensitized

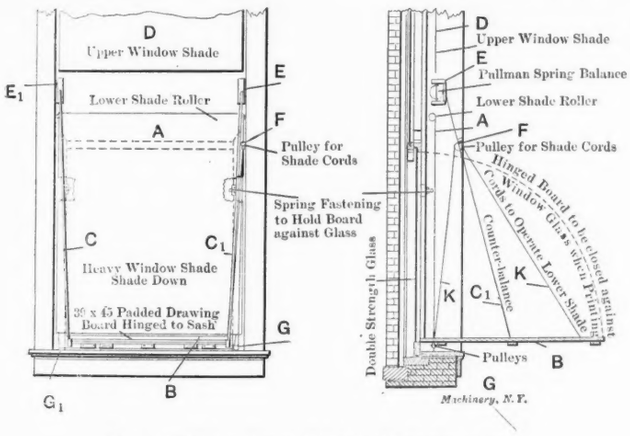



Fig. 3. Details of Board, Method of Suspension, etc.

paper is being inserted, and runs up out of the way as the board is raised to a vertical position against the window for printing. The cord operating the curtain passes down from its two lower corners through two pulleys in the window sill where one cord passes along the bottom sash to the other pulley. Here both cords ascend together to a third pulley on the casing where they both again descend a short distance and are attached to the board. The position of the third pulley on the casing and also the point of attachment to the board must be adjusted so that the cord distance from this pulley to the point of attachment when the board is in a horizontal position is equal to the distance the shade must travel down to shut out the light. When printing, the regular shade is drawn to where the other roller is attached, thus shutting out the light from the upper window.

When not in use the hinge pins may be drawn, the suspenders and shade cords unhooked and the board removed, leaving the window entirely unobstructed and no floor space occupied. If but one print of a tracing is wanted, fasten the tracing on top of the sensitized paper by putting at each corner a common pin through both and into the padded board. When the board is pressed against the window it will hold the tracing smoothly and firmly against the paper.

When a considerable number of prints are to be made from one tracing this apparatus is exceptionally rapid. Take four pieces of chamois, ½ by 1½ inches, at one end of which are attached two or three small rubber bands looped together. Pin one of these pieces to each of the corners of the tracing and draw the rubber bands over the edges of the board and hook them over the heads of brass tacks placed along the edge of the board on the back side. Then to make any number of prints cut the paper to size and slip it under the tracing, raise the board against the glass, expose a sufficient interval, then drop the board, draw the paper out, and wash it. With this arrangement, using fast paper and good sun light, one large print every 70 seconds has been made. If working during a heavy rain storm the tracings are protected from water, everything about the apparatus being inside the room.

The writer has also found it very convenient and economical when making prints from drawings on ordinary paper such as pamphlet leaves and from vandyke negatives to saturate them uniformly with oil of vaseline, blancholine, or glycerine, making sure to rub off any surplus oil which might soak into the blueprint paper during the time of printing and thus prevent it from washing. This process makes it possible to obtain blueprints from most any cut or drawing without the extra cost of first having it traced, it also makes the slow vandyke negative print in about one-third of the usual time.

To place notes in a permanent and convenient form for blue-printing have them typewritten (leaving such spaces as may be necessary for figures which will be drawn in afterward) on a thin strong transparent paper with a carbon on its back thus making the letters dense. To prevent the carbon from rubbing off use an atomizer and blow on it a shellac fixitive used for fixing charcoal drawings. When the fixitive is dry, oil the sheets as described above and they are ready for printing.

The following statement of the costs of apparatus to take a 3 by 4-foot tracing includes that just described and the ordinary blueprint frame, together with the high-priced appliances.

| | |
|---|---|
| (1) One of the best electric machines (listed) | $500.00 |
| (2) Vacuum sun frame (listed) | 75.00 |
| (3) Felt cushion sun frame (listed) | 80.00 |
| (4) Apparatus above described | 6.87 |
| The last named is itemized as follows: | |
| 1 Drawing board | $1.75 |
| 2 Pullman spring window counterbalances at 82½ cents | 1.65 |
| 2 yards of table padding at 70 cents | 1.40 |
| 1 window shade with mountings | 1.20 |
| 3 pairs hinges at 10 cents | 0.30 |
| 3 pulleys at 5 cents | 0.15 |
| 2 spring catches at 10 cents | 0.20 |
| 1 roll cotton batting | 0.12 |
| 12 feet of strong cord | 0.10 |
| Total | $6.87 |

To summarize, the device here described has the following advantages: (1) It is adapted to offices requiring a moderate amount of blueprinting, and where the more costly appliances cannot be afforded for lack of either means or space; (2) notwithstanding the large size of the board the counterbalancing device enables one to insert and remove the materials easily, with no annoyance in raising or lowering a large window; (3) minimum time of exposure and the protection of the tracings and operator from weather; (4) no dark room or boxes required to cut the small pieces of paper, but several tracings being printed on the full width of the roll and then cut apart in the full light after the prints have been dried.

* * *

William Koenig, the proprietor of a brass finishing shop in Brooklyn, was killed by the bursting of a new emery wheel which he was showing off to his workmen; he was struck in the chest by a large piece of the wheel and six of the workmen were seriously injured.

## PRACTICAL DONT'S FOR MACHINISTS.—3.

H. E. WOOD.

Don't blow into a hole that has dirt at the end of it.

Don't be afraid to tell your new ideas to your foreman.

Don't finger a piece of work while filing it in a lathe.

Don't use the side of your hammer to drive anything with.

Don't think all machinists are worth the same rate of pay.

Don't take advantage of your foreman's absence to "cut up."

Don't use a hollow-backed chisel for cutting oil channels.

Don't use a fine pair of dividers on rough and sandy scale.

Don't forget that O. K. means "Oll Korreckt," or all correct.

Don't try to grind a plug valve to a seat with coarse emery.

Don't try to make a flat surface with the tip end of a file.

Don't think that a farmer boy cannot learn to be a machinist.

Don't file a piece of work when it chatters beneath your file.

Don't use a hard hammer to drive a mandrel into a piece of work.

Don't stop your machine while in the midst of a finishing cut.

Don't cut a rawhide gear on slow speed, as a fast speed is much better.

Don't gage the amount of work you do by the amount of pay you receive.

Don't mark fine tools with steel letters—squares and scales especially.

Don't forget that large pieces of cast iron may be bent by peening them.

Don't throw away all the short butt ends, when you are cutting up stock.

Don't bore out the lathe chuck when you are boring a piece of work in it.

Don't put a lot of "gingerbread" polish on work that does not require it.

Don't set a tool to take a finishing cut, without using an oilstone on it.

Don't try to rough out and finish large screw threads with the same tool.

Don't fit a bracket on a machine and leave its bolting surface crowning.

Don't think that what you know about a machine nobody else can find out.

Don't forget that your fingers are softer than gears, or iron of any kind.

Don't forget that the closer you can get your toolrest to the work, the better it is.

Don't make a piece of work to a blueprint and have it look like something else.

Don't forget that the warmth of your hand will increase the diameter of a shaft.

Don't mark machine part numbers bottom side up, when you are erecting a machine.

Don't build a machine with castings that have molding sand still sticking to them.

Don't drive a key into place unless you have some means of getting it out again.

Don't grind a tool to cut machinery steel the same shape as you would to cut tool steel.

Don't carry dirty tools back to the store room, for the storekeeper to clean off.

Don't use a long neck planer tool, when you can get at your work with a short one.

Don't serve an apprenticeship without learning to dress and temper your own tools.

Don't forget that a universal lathe chuck should be tightened at all of its screws.

Don't start up the engine without letting off the condensed steam in the cylinders.

Don't boast that you can grind a cutting tool of any kind better than anybody else.

Don't say "I don't think that is right because I never saw it done that way before."

Don't put greasy fingers on cast iron either before or while taking a finishing cut.

Don't leave a shop, without leaving a clear record, so you may come back to it again.

Don't forget to see that your cutting tool has clearance back from the cutting edge below the chip.

Don't squirt a tablespoonful or more out of an oil can to find out what kind of oil is in the can.

Don't take three or four stock (or roughing) cuts when you can take all of the stock off with one cut.

Don't believe that a man can learn the machinist trade thoroughly in one shop or in three years time.

Don't spit tobacco juice on the floor where the erecting man has to crawl around on his hands and knees.

Don't forget that the kiud of oil used has a great deal to do with the working of a drill, tap, or reamer.

Don't say "there was not stock enough to finish up to size" after you have made a piece of work too small.

Don't forget that a lathe tool will make a brighter and smoother finish with water than it will if run dry.

Don't line up a shaft and pour babbitt bearings without making allowance for the sag in center and ends.

Don't use the tail end of your vise for a "chopping block" in cutting off sheet metal, etc., with a chisel.

Don't put a planer strap between your packing pieces, if you can possibly get it directly over the packing.

Don't get the "bighead" just because you can do a job or two, or if someone has told you that you are smart.

Don't forget that if a shaft gets to cutting, or is "froze," kerosene oil is the best thing to start it loose with.

Don't forget that a drill will make a hole larger than its own size when one lip is longer than the other one.

Don't start to turn up a job on lathe centers unless you know that the centers are both in line with the ways.

Don't tell the foreman that you are an all-around machinist, if you are only a specialist on one kind of work.

Don't put nuts on studs unless the thread is cut far enough down to allow the nut to go fully up to its place.

Don't ask for a "soft snap" running a machine when you can get a "good snap" running a hammer, chisel, and file.

Don't forget that you can handle a tailstock spindle faster with a wheel than you can with a cross-bar and handle.

Don't forget that paper, laid between two flat, smooth surfaces of iron, will help them wonderfully from sliding.

Don't run a machine reamer in a piece of work in the lathe chuck unless you know that the tail center is in line.

Don't say you have done all that can be done for a machine, when you have only done all that you know how to do.

Don't use a square to square up a tap unless you keep the stock flat down on the surface you want to square from.

Don't let a lathe or planer tool cut out into cast iron scale if you can possibly get under all of the scale with the first cut.

Don't forget that the machine you are running and the space you are occupying, have to be paid for just as well as *your* time.

Don't believe that lard oil is the only solution that is good to use on dies or tools in cutting threads, or wrought iron parts.

Don't bore a large steam engine cylinder when lying in a horizontal position if you can possibly do it in a vertical position.

Don't forget that where a thick and thin jamb-nut are used, the thin nut should go on next to the work and the thick one on top.

Don't get into the habit of trying every piece of work you make into the place it goes, but learn to depend upon your calipers.

Don't be content with knowing just what "shop kinks" you have learned from someone else, but investigate and work out a few yourself.

Don't file a shaft over a keyseat, in a lathe, if it is necessary to reduce the size; either take a cut with the lathe tool, or draw file it.

Don't forget, in tapping babbitt metal, lead, or any such soft stuff, to take the tap out and clean it after each full turn in.

Don't believe that a piece of work can be laid out, and drilled, planed, or milled as accurately as if it were done in the proper jig.

# LETTERS UPON PRACTICAL SUBJECTS.

## HOW I MADE DEEP-HOLE DRILLS TWENTY YEARS AGO.

*Editor* MACHINERY:

I was greatly interested in the article by E. W. Norton on deep-hole drills in October MACHINERY, and I think a little ancient history on this subject may be of interest to you.

In 1884 or 1885 E. G. Parkhurst, M. D. Pratt, J. E. Woodbridge and myself, with others, organized the Hartford Tool Co., primarily to manufacture patent lathe tools of various kinds. The "Gardner & Woodbridge" thread tool, now called the "Pratt & Whitney" thread tool, was my patent, and it was for work on this tool that I made the special drill which later developed to the "deep-hole" drill. About two years later the absorption of the Hartford Tool Co. by the Pratt & Whitney Co. threw me out of business and I went to work for Pratt & Whitney under Mr. Heyer, on the "reamer job"—then in its infancy. The company were making up a stock of standard reamers. The drilling, or chucking, of the blanks was being done on hand turret machines. It had been decided to fit up two large "Spencers," *i.e.*, Hartford automatic screw machines, for this work, when the job was turned over to me by Mr. Heyer.

The blanks for the reamers were round tool steel and, as I remember, were made from 1¼ inch diameter by 2¾ inches long with ½-inch taper hole, to 3½ inches diameter by 4½ inches long, with 1¾-inch taper hole. The machines were fitted with common universal chucks. The first consideration was to get a hole through the blanks from end to end without withdrawing the drill or stopping the feed. As is usually the case with any new idea or invention, it is impossible now for me to say just when or how it came into my mind, but

Fig. 1. Blank for Deep-hole Drill.

thinking of a single-lipped drill I had made for a difficult cut on thread tools, I thought of putting a smaller groove opposite the large groove, covering it with a dove-tailed strip of metal, and connecting the small covered groove with a hole through the center of the drill shank and forcing oil through the hole and covered groove to the cutting point of the drill. I had had experience with the cutting action of single-lipped drills on thread tool work and when I had gotten the oil groove and connections thought out I felt confident as to the success of the thing. I took the idea to Mr. Heyer and he said, "It looks good. Go ahead and try it out," or words to that effect.

I started in on the smallest blanks at hand, which were, as I recollect, for 1 inch reamers and about 3 inches long. The first drill I made was 7-16 inch diameter (See Fig. 1.) The dimensions are from memory and are not claimed to be exact. I milled the large or cutting groove with a standard twist drill cutter, giving it a little less than the regular spiral. The end view at cutting point was about like Fig. 2. Exactly opposite I milled a deep narrow groove, making the end look like Fig. 3; the spiral was the same on both grooves. The small groove was about 5-32 inch deep and of the same width. I then made a small shank cutter and under-cut the sides of the smaller groove to the shape shown in Fig. 4. The small groove was carried up further than the large one and a hole was drilled from the top end to connect with the hole through the center of the shank. I next beveled a strip of sheet metal—do not recollect whether it was steel or brass as I afterwards used both—and crowded it into the dove-tail, so covering the narrow groove. I then soldered the strip in very carefully and had a continuous oil-tight pipe or hole from shank end to the cutting point of the drill.

The drill just described was held in the turret in a plain collet with a set screw Fig 5. The collet was connected at the center of the turret with a pipe from an oil-pump. This pipe was provided with a swivel joint, allowing the turret to revolve. To support the drill when starting, that is, to hold it true to the center, I rigged a rest on the cross slide, Fig. 6. It was made of steel and hardened. It came up automatically and held the drill full up to the center until the lip was in, say 1-4 inch, and then moved back out of the way. I do not know how much pressure the oil-pump gave but it would throw oil six or eight feet horizontally from the point of the drill. I do not recollect a first starting or trying-out of any job with so many untried and experimental features that proved so complete a success as that one did. At the first trial that 7-16 inch drill simply "walked right through" the 3 inches of steel, and kept it up hour after hour; I will not attempt to state what the record was, but my recollection is

Fig. 2.

Fig. 3.

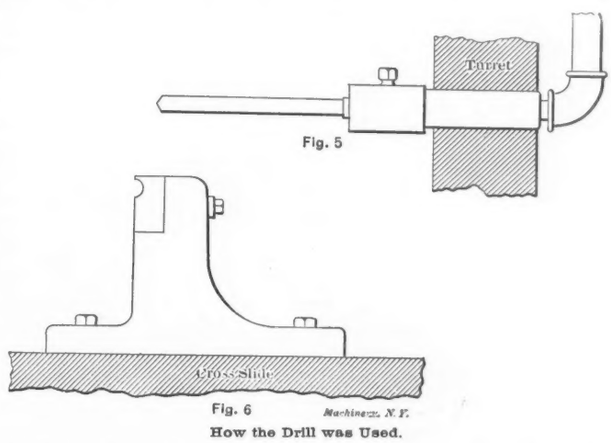
Machinery, N.Y.

Fig. 4.

that more than one hundred pieces were bored without resharpening the drill. On this particular size of reamer blanks I used two other tools in the turret—a roughing drill, enlarging the holes to about ⅝ inch, and a taper reamer. The oil for these was applied through the spindle of the machine from the back end, being switched automatically from the turret.

The successful outcome of this first trial encouraged me to believe that I could go further with the same idea; particularly when the moderate pressure used on the oil had proved so efficient in ejecting the chips. I told Mr. Heyer that I would like to make a drill smaller in diameter and considerably longer, and as before, was told to go ahead and try it out.

I then made a drill, which according to my recollection was 5-16 inch diameter and about 12 inches long. It was made in the same way as the shorter drills used on the reamer job. To test this drill I selected a piece of round tool steel about 1¼ inch diameter and 10 or 11 inches long. One end was held in the chuck on an old style Pratt & Whitney 13 inch lathe and the other end ran in the center-rest. The drill was held in the tool-post on the carriage. I do not remember exactly what kind of a holder I used but it was a temporary rig. I compounded the feed gears to get a very fine feed, but cannot say now what the feed was; probably it was not more than




How the Drill was Used.

0.002 to 0.003 inch per revolution. I put up a special countershaft to drive the oil-pump for "all that was in it." This pump was a small rotary affair but it did the work. I do not remember the details of this test so well as that of the reamer blanks. Neither can I say how the pump was connected to the drill—whether by a flexible hose or a telescoping pipe.

I do not remember just how long it took to feed the drill through the bar, but I *do remember* that after the drill was started it went entirely through the bar without a hitch, and that it made a beautiful hole. Further, I remember making a shield by taking the nose and bottom out of a tin oiler and

sliding what was left onto the drill, the top towards the shank. This caught and stopped the stream of oil which, otherwise, would have soaked everything and everybody in the vicinity. I remember distinctly the satisfaction I felt at hearing the chips strike the tin shield as they came out with the oil. This experiment was considered a success without further trial, and orders were given to fit up a 16-inch gibbed lathe for drilling the hole through lathe spindles.

I made two more drills of the same type which were (again trusting to memory) 3-4 inch diameter, and about 36 inches long. Two toolmakers assisted me in fitting up the lathe. We had the work nearly completed and ready for trial when I left Hartford for Chicago to work as salesman for C. H. Besly & Co., who were then Pratt & Whitney's western agents.

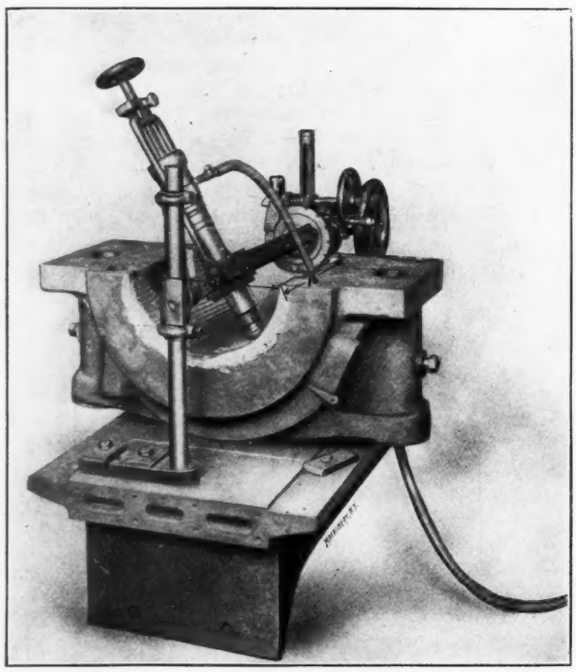
I am not familiar with the progress and development in the art of deep-hole drilling since then, but so far as I know this was the origin of the idea of forcing a liquid through the body of a drill for the purpose of cooling and lubricating the cutting point and forcibly removing the chips as fast as they were formed. Up to the point to which I carried it the idea was entirely new and original with me, and at that time I was recognized by the leading mechanics at Pratt & Whitney's as the inventor. If anyone can antedate me on the idea of "forcing oil in and chips out," I will accept the position of "also ran," but am willing to let the foregoing facts be published as a matter of history. F. N. GARDNER.

Beloit, Wis.

## PNEUMATIC BABBITT BEATING MACHINE.

*Editor* MACHINERY:

The pneumatic babbitt beater, shown in the accompanying illustration, was designed and patented by Charles Hightower, late assistant superintendent of the Union Iron Works, of San Francisco, Cal. It will undoubtedly fill a long-felt want in the machine shop—not only from a practical standpoint, but from an economical one as well.



Pneumatic Hammer arranged for Beating Babbitt in Bearings.

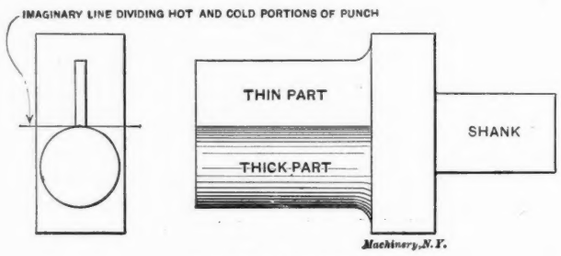
Beating babbitt by hand, as we all know, is very expensive and at the same time not altogether satisfactory. The job is usually done by one of the shop laborers, who does not understand the importance of properly beating the babbitt, until it is well into the dovetails provided for securing it in place, and at the same time closes up the pores of the metal, together with any possible blowholes that might have occurred in pouring, and to this fact may be traced a good deal of the trouble given by babbitted journals and surfaces. While the work done by the machine may also have its faults if the machine is not skillfully handled it will be seen that there is no comparison between the two methods of beating babbitt as far as the cost of production goes. The cap, shown in the illustration, is 16 inches long, with a bore of 15½ inches and it was beaten in nine minutes. The machine, as may be seen, is of very crude construction, having been built entirely for experimental purposes. As the principle is clearly shown in the cut, consisting of a suitable frame for holding and traversing a pneumatic hammer an explanation as to the construction and operation is hardly necessary; sufficient to say that it gives entire satisfaction and promises to be a welcome addition to the modern machine shop.

San Francisco, Cal. W. S. ATKINSON.

## HARDENING WITHOUT CRACKING.

*Editor* MACHINERY:

I have a method of hardening intricate shapes without cracking that I desire to place before others. This method does not deal with special baths, special appliances to hold the work in proper position when dipping, gas furnaces, etc., but with the old-fashioned charcoal fire which the majority of us are obliged to use. These "special appliances" are of little value to us toolmakers who are confronted with "Use what appliances you have; do not rig up anything special." If my method of hardening is followed to the letter, there will be few cases of cracked dies. I have used charcoal fire and the following manner of hardening for the past twelve years and have yet to crack my first die.




Punch to be Hardened.

The first operation is heating. Do not prepare a die for fire by plugging up the screw holes with fire clay. For when the die becomes warm the water is evaporated from the fire clay, causing the clay to shrink away and allowing steam and hot water to get in between the clay and hole, thus raising more deviltry than if the hole had been left open for the water to flow freely through it. Place the article in the fire, with a slight draft blowing, and change its position frequently to insure uniform heating. Too much importance can not be attached to even heating, as this is the ground work of successful tempering. It should be borne in mind that steel expands nearly one-eighth inch to the foot when at bright heat. Therefore if one-half of a die is dark red and the other half is bright red, it is clear that one-half of the die has expanded more than the other half, thereby causing forces to push against each other. This condition tends to warp the die while it is hot. And if the die is dipped while in this state, as is too often done, there will be uneven contraction, causing internal strains, strongest along the line that divided the two shades of red, and causing a "set" in the die that holds it in a curved line caused by one end of the die expanding more than the other and pushing that end out of a true line.

Young fellows, follow carefully while I attempt to explain in my homely way what I have found to be the greatest cause of cracks when tempering. If you catch the point I am trying to make clear, you need have no fear when immersing an expensive die in the bath. For example, we will harden the punch, Fig. 2. We heat this punch carefully and evenly in a charcoal fire or gas furnace. For a bath we have a tub of clear water. The punch is removed from the fire the instant the proper heat is attained. We now immerse the punch in water, but do not allow water to remain at the same level on punch, as this causes either a crack or a huge swell, as will be shown later. Now place one hand down in the water and keep feeling of the punch. The moment that you can bear your fingers on the punch, remove it from the bath. Under no

consideration must you allow the punch to become cold in the bath, for this is just what causes cracks, for this reason: When we immersed the punch the slender stem was immediately attacked by the water, contracted to its normal size and became cold and hard, while the body of the punch was still red hot. This caused a distinct line between the hot and cold portions of the punch shown by the imaginary line in the cut. Now, as the body of the punch begins to cool and contract, it is obvious that it must certainly be pulling away from the stem, which is already contracted. If a crack does not appear, it is no sign that it will not sooner or later, as there certainly must be a tremendous internal stress which will crack the punch later, and the operator will be taken to task for his carelessness. But, on the other hand, if we remove the punch as soon as we can bear our fingers on it in the bath (when it is still so hot that it steams), then the heat from the body of the punch will run out into the slender portion and the contraction will be uniform, excepting for the little effect the atmosphere may have.

The above could be written in a very few words, thus: "To prevent dies cracking, do not allow them to become cold in the bath."

FRANK E. SHAILOR.

Great Barrington, Mass.

## DIMENSIONS OF EQUAL SECTION AND ECCENTRIC PISTON RINGS.

*Editor* MACHINERY:

The accompanying tables of equal section and eccentric piston rings are very useful to shop men and others; I have used them for some years, and know them to be right.

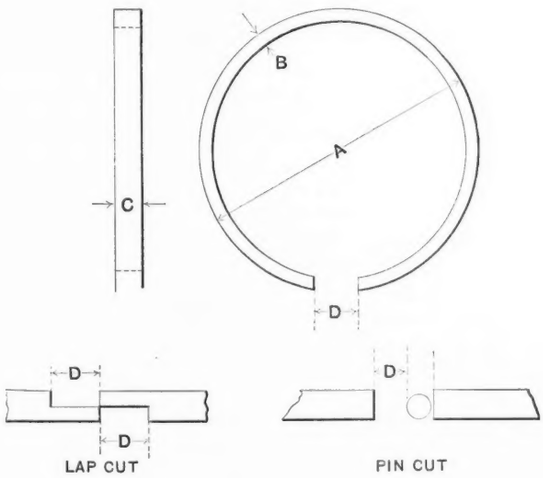



TABLE OF DIMENSIONS FOR EQUAL SECTION RINGS.

| LETTERS | DIAMETERS, OF CYLINDERS, IN INCHES. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| A | $6\frac{5}{32}$ | $7\frac{5}{32}$ | $8\frac{3}{16}$ | $9\frac{3}{16}$ | $10\frac{7}{32}$ | $11\frac{1}{4}$ | $12\frac{1}{4}$ | $13\frac{9}{32}$ | $14\frac{9}{32}$ | $15\frac{5}{16}$ | $16\frac{11}{32}$ | $17\frac{11}{32}$ | $18\frac{3}{8}$ | $19\frac{13}{32}$ | $20\frac{13}{32}$ |
| B | $\frac{1}{4}$ | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{15}{32}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{19}{32}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{6}{4}$ | $\frac{13}{16}$ |
| C | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{6}{8}$ | $\frac{7}{16}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{9}{16}$ | $\frac{11}{16}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{13}{16}$ |
| D | $\frac{35}{64}$ | $\frac{39}{64}$ | $\frac{21}{32}$ | $\frac{23}{32}$ | $\frac{25}{32}$ | $\frac{27}{32}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 | $1\frac{1}{16}$ | $1\frac{1}{8}$ | $1\frac{3}{16}$ | $1\frac{1}{4}$ | $1\frac{9}{32}$ | $1\frac{11}{32}$ |

Augusta, Ga.

C. R. MCGAHEY.
Supt. Lombard Iron Works.

## A ROUND PLUG IN A HOLE OF THE SAME DIAMETER.

*Editor* MACHINERY:

"Perplexed," in MACHINERY for November, treats in an interesting way, the question as to whether or not oil takes up space; he also details experiments made with a view to determine whether a hole of a given diameter can be entered by a plug of corresponding diameter. The matter is one of specific interest, and that the subject is worthy of discussion is evident, from the editor's point of view, by the note in answer to the statement by "Perplexed." The questions involved are of a nature to awaken study and thoughtful difference of opinion in their elucidation.

Theoretically, it seems to me easily provable that for a plug to enter a hole it must be smaller than the hole. But to test the matter practically! There's the rub. If under the most painstaking and scientific treatment of a ring gage and plug it is determined that they are of similar size, and with or without lubrication fit together, why may not some iconoclastic mechanic suggest that there may be one or two molecules of divergence from exactness?

In Avery's Natural Philosophy, it is stated that "a molecule is so small that a total of 8,000,000,000 molecules of water is barely visible in the best of modern microscopes." An atom, again, is smaller than a molecule. The minute quantities of oil, whether atoms or masses that find their way into interstices between highly polished bearing surfaces, must be infinitesimal, but that there are such interstices which are filled by space-taking oil, is probable if not easily demonstrable.

Perhaps the independent opinion of an eager and experienced physicist, who had not read the article in MACHINERY, but who kindly dictated a note in answer to the questions raised by "Perplexed," may be read with pleasure and profit. This opinion, it may be added, was given by a man whose name would be instantly recognized by nearly all of your readers as an authority in his special field. He says:

"In reference to this matter, I would say that oil certainly does take up space. If there is no space for it, one of two things must happen: The surrounding material will be compressed or diminished in size to give the oil the room at the same time that the oil will be compressed and diminished in size, or the other thing that may happen is that the oil will squeeze out, for it will have to get out of the space if there is no room for it.

"As to the inquiry whether a plug can enter a hole of the same diameter, I should say that it certainly can. If pressed in, the hole will stretch a little, and the plug shrink a little by compression. In consequence of this, a plug of a little larger diameter can enter a hole smaller than itself, and it will depend upon the extensibility and compressibility of the materials of the plug and that which surrounds the hole how much one will give way to the other. There really need be

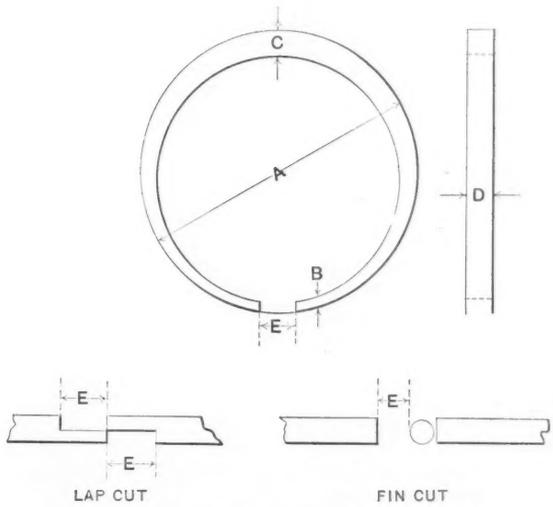



TABLE OF DIMENSIONS FOR ECCENTRIC RINGS.

| LETTERS | DIAMETERS, OF CYLINDERS, IN INCHES. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| A | $6\frac{5}{32}$ | $7\frac{5}{32}$ | $8\frac{3}{16}$ | $9\frac{3}{16}$ | $10\frac{7}{32}$ | $11\frac{1}{4}$ | $12\frac{1}{4}$ | $13\frac{9}{32}$ | $14\frac{9}{32}$ | $15\frac{5}{16}$ | $16\frac{11}{32}$ | $17\frac{11}{32}$ | $18\frac{3}{8}$ | $19\frac{13}{32}$ | $20\frac{13}{32}$ |
| B | $\frac{3}{16}$ | $\frac{7}{32}$ | $\frac{1}{4}$ | $\frac{9}{32}$ | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$ | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{15}{32}$ | $\frac{15}{32}$ | $\frac{1}{2}$ | $\frac{17}{32}$ | $\frac{9}{16}$ |
| C | $\frac{9}{32}$ | $\frac{5}{16}$ | $\frac{11}{32}$ | $\frac{3}{8}$ | $\frac{13}{32}$ | $\frac{7}{16}$ | $\frac{15}{32}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ |
| D | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{9}{16}$ | $\frac{11}{16}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{13}{16}$ |
| E | $\frac{35}{64}$ | $\frac{39}{64}$ | $\frac{21}{32}$ | $\frac{23}{32}$ | $\frac{25}{32}$ | $\frac{27}{32}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 | $1\frac{1}{16}$ | $1\frac{1}{8}$ | $1\frac{3}{16}$ | $1\frac{1}{4}$ | $1\frac{9}{32}$ | $1\frac{11}{32}$ |

*Machinery, N. Y.*

no mystery about the matter, and I cannot see that it is a complex physical problem, depending upon the definition of the forms used. I would ask another question in this connection. Where will you find measuring apparatus so accurate that you can *measure* the plug and the diameter of the hole and say that they are absolutely of the same diameter? All measurement involves error, no matter how refined it is.

"Another question arises. Where will you find means so accurate that you can *make* the plug and the hole of exactly the same shape, say absolutely circular? You cannot do it. Moreover, the plug and the hole would have to be made of either the same material and kept at the same temperature absolutely, or the coefficients of expansion of the materials would have to be allowed for in the sizes of the holes and the plug at any given temperature."

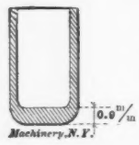
I trust the foregoing may add something to this discussion. It will be noted that the difficulties of construction and measurement are emphasized in the above expert comment.

Lynn, Mass. LYNN READER.

## FINDING THE SIZE OF BLANK FOR A CUP.

*Editor* MACHINERY:

One of our customers wanted us to build a double hydraulic press for making cups, as shown in the sketch, the cups being the first operation for nickel-jacketed steel bullets. He sent us a sample piece from which latter one I had to find the dimensions for the blank which, of course, is a flat round disk. I found that the thickness of sheet metal from which the cup had been drawn was 0.9 millimeter at the bottom of the cup. The diameter I found as follows: I made use of the physical principle enunciated by Archimedes, which is that any body immersed in water weighs as much less as the weight of the water it displaces. Therefore, in the metric system, the volume of water displaced expressed in cubic centimeters times 1 is the weight of this volume in grammes. This fact makes the proceeding simple. First, I found the absolute weight of the cup in air, and second when suspended in water, by means of a chemist's scale. Weighed in air it was 2.923 grammes, and in water 2.55 grammes, the difference in weight being 0.373 grammes or cubic centimeters. From this data the diameter of the blank was figured by the following formula:




$$V = \frac{0.09\, d^2\, \pi}{4}, \text{ in which}$$

$V$ = volume.

$d$ = diameter of disk.

$\pi = 3.14$.

Transposing $d^2$, extracting square root and substituting 0.373 for $V$ we have, successively.

$$d = \sqrt{\frac{4\,V}{0.09\,\pi}} = \sqrt{\frac{4 \times 0.373}{0.09 \times 3.14}} = 2.298 \text{ centimeters diameter}$$

of disk.

Berlin, Germany. OTTO ECKELT.

[The method of obtaining the diameter of the disk described by Mr. Eckelt is also interesting in that it shows the facility with which computations in volume and weight can be interchangeably effected in the metric system. The fact that the units of weight, capacity and extension are all based on the meter saves the laborious process necessary with our awkward English units.—EDITOR.]

## SETTING CUTTERS ACCURATELY ON THE UNIVERSAL MILLING MACHINE.

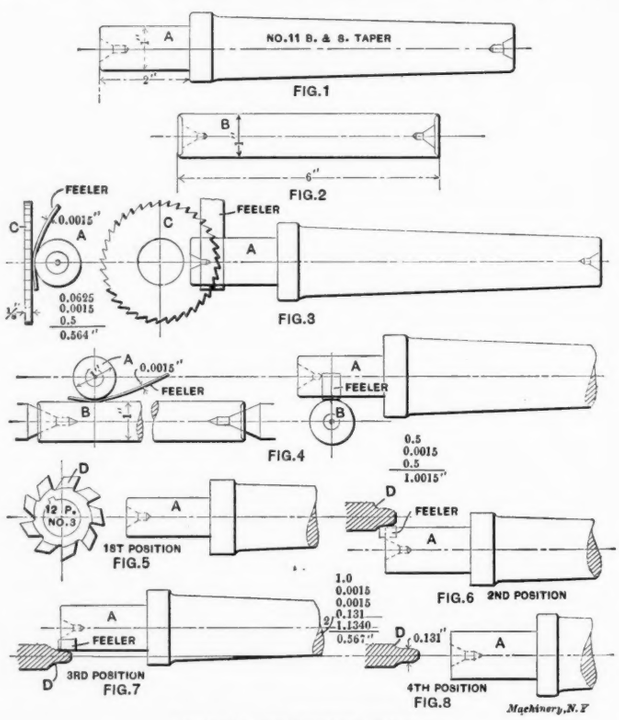
*Editor* MACHINERY:

To accurately set cutters on a milling machine by the following described method it is necessary that the several enumerated conditions be found in the machine and that the simple tools described be provided: 1. The platen or table screw, cross-slide or saddle screw and the knee or vertical screw each have a dial graduated to read in thousandths of an inch. 2. No lost motion between screws and nuts. 3. The platen or table set at right angles to the cone spindle. 4. The dividing head center and tailstock center in perfect alignment. 5. A steel plug center and straight arbor, hardened and ground, of the form illustrated in Figs. 1 and 2.

We will first consider the setting of an ordinary slitting saw. Place the saw on the cutter arbor in the cone spindle. Place the plug center, Fig. 1, in the dividing head spindle and move the dividing head so as to bring the plug center against the side of the saw as shown in Fig. 3. Adjust the plug center so that a standard feeler can be just drawn from between the saw and plug. Set the dial on the cross-slide screw to zero. Now, half the thickness of the saw plus the thickness of the feeler plus half the diameter of the plug center will be the distance to move the plug center by the cross slide screw to bring the saw exactly on the center. In this example it is 0.564 inch and of course can be directly measured by reading the cross-slide dial.

In order to set an end-mill or drill centrally it will be necessary to place the plug center in the cone spindle and to mount the standard arbor, Fig. 2, between the index centers, as shown in Fig. 4. Then raise the knee until the plug center and standard arbor are in the relative position illustrated in Fig. 4, with a standard feeler between them. Set the dial on the vertical or knee screw to zero. Having done this remove the plug center and the spindle arbor from the machine. Raise the knee by means of the vertical screw half the diameter of the plug center plus the thickness of the feeler plus half the diameter of the standard arbor and the machine will be set to use either the drill or end-mill. The distance the knee will have to be run up in this example is 1.0015 inch. It will be seen that by making the plug center and spindle arbor each one inch diameter it greatly facilitates the calculations.

In setting form gear cutters it is generally the custom to set the cutters centrally by having a center in the dividing head with a very sharp point and setting the point of the center to the line which is usually scribed on the top or back of the teeth of the cutter. But in the method to be described this line is not required and may be ignored. We will assume,




Setting Milling Machine Cutters.

however, that both sides of the tooth of the cutter are exactly the same shape and that the tooth is at right angles to the axis of the cutter. In short, that the cutter is symmetrical. Now place the gear cutter on the cutter arbor which is mounted in the cone spindle, being sure that the faces of the cutter and arbor bushings are free from dirt as otherwise the cutter will not run true. Place the plug center Fig. 1 in the dividing head spindle and put the gear cutter in the position as illustrated in Fig. 5 so that the centers of the cutter and plug center are approximately in the same horizontal line. In the second position shown in Fig. 6 place the plug center so that its end touches the side of the cutter tooth at about the pitch line.

Set the dial on the table screw and cross-slide screw to zero. Move the plug center away from the cutter in a longitudinal direction until there is sufficient room to pass in front of the cutter, and note the number of turns of the table screw that are required to accomplish this operation. In the third position, Fig. 7, the plug center is placed back in its original position longitudinally, but is moved over sideways so that it touches the cutter tooth on the opposite side at about the pitch line position. In making the cross slide move it will be necessary to note the number of thousandths on the cross-slide screw dial that are required. Now move the plug center away from the cutter in a longitudinal direction by means of the table screw so that the center plug will again pass in front of the cutter, and then change its lateral position by means of the cross-slide screw, one-half the number of thousandths that were required to move the plug center from the second position, Fig. 6, to the third position, Fig. 7. This will bring the cutter into the fourth position, Fig. 8, and it will be located accurately in the central position relative to the cutter.

This method applies not only to form gear cutters but to concave, convex and double-angle cutters, provided the angle cutters are of same angle on each side of the center line. In setting a concave cutter by this method it will be necessary, of course, to use a plug center small enough to enter the groove and clear one side while touching the other side of the tooth. It is much easier to set this form of cutter because after having the machine set longitudinally it will be only necessary to move the plug center from one side to the other. The above methods may be used for a vertical milling attachment by utilizing the spindle of the attachment instead of the cone spindle.

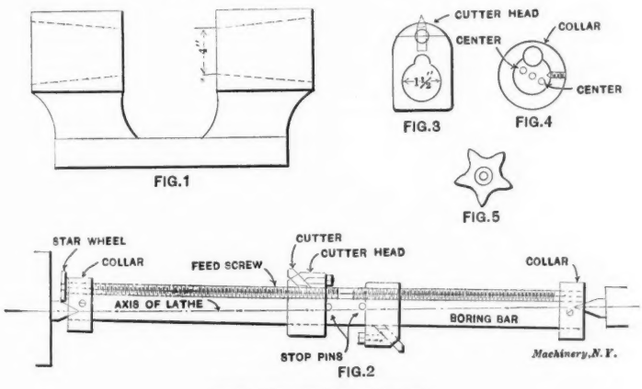
WILLIAM C. FORCE.

North Plainfield, N. J.

## BORING BAR FOR BORING TAPER HOLES.

*Editor* MACHINERY:

In looking over a back number of MACHINERY I came across a description of a special boring bar for boring taper holes. It put me in mind of a bar that caught my attention during a visit which I made to a strange shop. It struck me as about the cleverest arrangement for boring taper holes that I ever had my attention called to. Thinking it might be interesting to some of your readers, I send a sketch of it along with this description.




Boring Bar for Taper Holes.

The bar in question was at work boring out taper holes, in what looked like the bearings of a grinder, Fig. 1. The head had a double bearing with the holes tapering outward. The work was held in a fixture fastened to the carriage of the lathe, and one setting was sufficient for any number of pieces. The bar was about 1½ inch diameter by 24 inches long and was ground to size. With a ¾-inch forming mill, a round groove ½ inch deep was cut in one side of boring bar, to allow for the feed screw, Fig. 2. This feed screw was cut with a right-hand thread on one end and a left-hand thread on the other. Small cutter heads were bored out to fit the bar, and tapped out, one right and the other left, to engage the feed screw, similar to a half nut. I presume these heads were tapped out before the 1½-inch bearing hole was bored. The heads were a sliding fit on the bar and controlled by the feed screw. Fig. 3 is an end view of head showing its general appearance. The taper was obtained by having the centers of the bar drilled off the true centers at opposite points, thus apparently imparting a wobbling movement to the bar. Thus the center of bar would practically run true, where the heads were started from, gradually increasing the throw until at the extreme ends. The feed screw was held in place by cast-iron collars on either end, as per Fig. 4, and was driven by the star wheel, Fig. 5. The cutter was a piece of square high-speed steel held in place by a setscrew. Stop pins in the bar insured the heads starting from the same point each time. Fig. 4 shows how the centers were drilled to give the necessary throw.

TEXAS.

## ANGLES OF SCREW THREADS.

*Editor* MACHINERY:

The following table was compiled to simplify and shorten the process of finding the angles made by screw threads. There is but one operation, that of division, and a table of tangents is unnecessary. While the results obtained by the short method first given are not strictly accurate, they are practically so, for the greatest error is less than one minute for all ordinary diameters and pitches.

The first column of the table contains the number of threads per inch, from one to twenty-four. The second column gives the angles in degrees and fractions of a degree, made by helices of 1 inch to 1-24 inch pitch and 1 inch diameter. To find the angle made by a helix of a given diameter and pitch, find in the first column the given pitch and take the angle opposite this in the second column. The angle taken, divided by the given diameter of helix, equals the angle sought.

For example, if the angle to be found is the average of those made by the top and bottom of a square thread 1¼ inch diameter and four threads per inch, that is to say, of a helix 1⅛ inch diameter then $4.55 \div 1.125 = 4.04$ degrees $= 4$ degrees 2.4 minutes. The angles made by the top or bottom of the same thread can be found, if required, by dividing the same constant by the respective diameters. If the exact angle is required, the constant in the third column and opposite the given pitch, is divided by the diameter of the given helix. The quotient is the tangent of the required angle, which must be found in a table of natural tangents.

To illustrate, by using the diameter and pitch mentioned in short method, $0.07958 \div 1.125 = 0.07074 =$ tan 4 degrees 2.7 minutes.

| Threads per inch. | Angle for 1 inch diameter. | Constant = $\frac{\text{Pitch}}{3.1416}$ |
|---|---|---|
| 1 | 17.66° | .31831 |
| 2 | 9.04° | .15916 |
| 3 | 6.06° | .10610 |
| 4 | 4.55° | .07958 |
| 5 | 3.64° | .06366 |
| 6 | 3.04° | .05305 |
| 7 | 2.60° | .04547 |
| 8 | 2.28° | .03979 |
| 9 | 2.03° | .03537 |
| 10 | 1.82° | .03183 |
| 11 | 1.64° | .02894 |
| 12 | 1.52° | .02653 |
| 13 | 1.40° | .02449 |
| 14 | 1.30° | .02274 |
| 15 | 1.22° | .02122 |
| 16 | 1.14° | .01989 |
| 17 | 1.07° | .01872 |
| 18 | 1.01° | .01768 |
| 19 | .96° | .01675 |
| 20 | .91° | .01591 |
| 21 | .87° | .01516 |
| 22 | .82° | .01431 |
| 23 | .79° | .01384 |
| 24 | .76° | .01326 |

Meriden, Conn. T. E. WELSH.

* * *

The following three recipes for fastening wood to tin plate should also be useful for joining other materials of dissimilar characteristics that are required to be cemented together: 1. Dissolve 1 part pure India rubber, cut fine, in 5 or 6 parts of benzine or carbon disulphide. 2. Soak 1 ounce of glue in water for 12 hours, remove, melt down and add 1 ounce brown sugar, 1 ounce gum arabic, and 4 ounces of water; apply hot. 3. Dissolve 1 part of shellac in 3 parts of strong ammonia.

# SHOP KINKS.

**A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.**

**Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.**

### TO PREVENT TOOLS RUSTING.

A lump of unslaked lime, placed in a box with bright tools, will prevent rust, as it absorbs moisture. The lime should be renewed occasionally. C. P. L.

### TO POLISH WOOD HANDLES.

Rub with a piece of waste dipped first in linseed oil, then in shellac. After rubbing, allow it to stand, then rub again, dipping alternately into the oil and the shellac. This gives a very high polish, which will not scratch nor flake off.

St. Johnsbury, Vt. W. H. SARGENT.

### TO CLEAN STAINED BOTTLES

A good way to get the stains out of bottles is to fill them half full of water and then put in a handful or two of cast iron borings, coarse ones preferred; shake well. It will clean any bottle no matter how badly it is stained. The boys in our shop use it for cleaning their tea bottles and it works all right.

Toronto, Ont. GEO. WILLIAMSON.

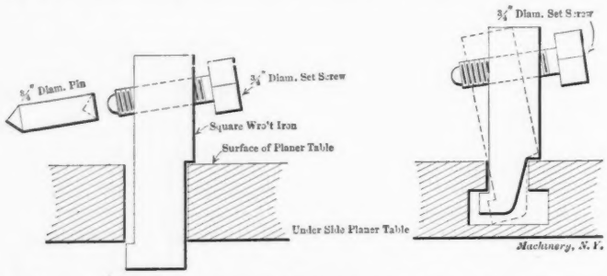
### TO PRESERVE SCREWS, ETC.

Some toolmakers—and others—like to save their small old screws, nuts, etc., the common practice being to keep them in small tin boxes where they soon become rusty and unfit for use. A good way to keep such scrap or new screws of various sizes, is to keep them in small large-neck bottles, each provided with a cork and labeled if desired. In this way one can always see instantly just what they have and how many of each and the pieces never get rusty. CARROLL ASHLEY.

Rochester, N. Y.

### CHUCKING PIECES FOR PLANER WORK.

The illustration represents chucking pieces for planer work, which for folding flat work like locomotive frames, frame tongues, etc., on a planer table beat anything I have ever used. I make them out of 1¾-inch square iron, cut off to proper length; a number of them are chucked and planed




out as shown. The pins or fingers are ¾-inch soft steel, case-hardened, and I have an assortment from ½-inch to 8 inches in length. The long chucking pieces I use in square holes in the table, the short ones in the grooves. In using I drive punch marks into the work for the point of the finger to set in. A. F. BIERBACH.

Milwaukee, Wis.

### HINTS ON HARDENING.

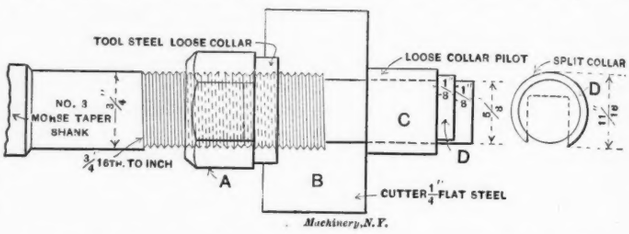
Only those who have had some experience in hardening a variety of small tools will understand or appreciate thoroughly what is about to be said.

I have experienced, in hardening, that some water does not take kindly to the hot pieces of steel, but rather stays away from it, as it would from a stick coated with tallow. The result is the tool is not hard. To overcome this, add about one-third muriatic acid to the water and the result will be surprisingly improved.

Here is something that toolmakers are meeting with every day, *viz.*, small and delicate-shaped tools are to be hardened, and it is a question in the mind of the workman whether to use water or oil to harden in. Water may crack the tool and in oil it may not harden, but suppose he tries oil and it does not harden the first time; the second time of heating and dipping will most surely crack it and the work is spoiled. For such work I have used a mixture of one-half water and one-half glycerine with best results; this mixture never fails to harden and I have never had a piece spring out of shape or crack when dipped in it. L. S. B.

### BORING OR FACING BAR.

The sketch shows a boring or pin facing bar, which will be found very convenient for facing for heads of bolts or nuts; also for counterboring. This size is made to take ¼ inch flat tool steel of any width up to 1¼ inch. By slipping off the split collar, any size pilot collar can be put on. The pilot




collar must be of such length that the cutter will rest on it instead of bearing on the bottom of the slot in the bar. This is necessary, of course, to keep the split collar in place. I would advise making all parts of this bar, except the nut, of tool steel.

Marquette, Mich. CHAS. V. KINSMAN.

### BLUING FOR LAYING OUT WORK.

When a small amount of marking or laying out of work is to be done, on steel, brass, iron, or copper, apply with the finger a thin coat of Prussian blue, such as is sold in thin metal tubes, at artists' supply, and paint stores. This does away with the objectionable feature of repolishing the work after it is completed, as it can be easily rubbed off, after the work is finished. It is far ahead of red lead for surface scraping work, and fits for punches, dies, etc., as it is more plainly seen. FRANK G. STERLING.

Lowell, Mass.

### TO TEMPER A TWIST DRILL TO DRILL HARDENED STEEL.

Holes may be drilled in tempered steel, such as circular saws, springs, music wire, etc., by hardening an ordinary twist drill in sulphuric acid. The pure acid should be placed in a saucer or other flat-bottomed vessel to a depth of about ⅛ inch. The point of the drill is heated and dipped in the acid to that depth, making the point extremely hard, while the remainder remains soft. If the point should break, reharden as before, but have a little less acid in the vessel. In this manner the drill may be hardened just enough to drill the steel, but not brittle enough to break when coming through.

New York. H. J. BACHMANN.

### TO REPAIR FROST-CRACKED WATER-JACKETS.

Among the ways of repairing frost-cracked water-jackets of gasoline engines might be noted this: A patch was made of stiff band iron, long enough to cover the crack, and 2½ inches wide; then there was cut out of some heavy asbestos mill board two thicknesses of the same size, the whole center of which was removed, leaving only a rim about ½ inch wide. This rim of packing was then laid over the crack and packed full of a mixture of equal parts of fine cast-iron borings and finely powered quicklime; then the iron patch was clamped tightly over it and the jacket filled with water. The expansion of the lime, when wet, forced the mixture into the crack, which soon rusted tight enough so that the patch was removed, the surplus lime scraped off, and the job finished up with a coat of paint. W. D. GRAVES.

Brown's Valley, Minn.

* * *

An error obvious to any one who ever uses logarithms occurred in the October data sheet, the logarithm of 1 being given as zero. The same also applies to the square, cube, square root, and cube root of 1.

## SHOP RECEIPTS AND FORMULAS.

**This page will be used for the publication of shop receipts which the contributors know from experience to be practicable. Nearly all readers of MACHINERY can add something, and it is desired that they use this page as a medium for exchanging useful formulas, thus putting them on record for the general benefit of the craft. All published receipts are paid for.**

### 135. COMPOUND FOR CLEANING BRASS.

To make a brass cleaning compound use oxalic acid, 1 ounce; rotten stone, 6 ounces; enough whale oil and spirits of turpentine of equal parts, to mix, and make a paste.

Dayton, Ohio. G. E. HETZLER.

### 136. CEMENT FOR IRON AND MARBLE.

For fastening iron to marble or stone a good cement is made as follows: 30 parts plaster paris, 10 parts iron filings, ½ part sal ammoniac mixed with vinegar to a fluid paste fresh for use. R. M.

### 137. ANTI-FREEZING SOLUTION.

A solution for water jackets on gas engines that will not freeze at any temperature above 20 degrees below zero may be made by combining 100 parts of water by weight with 75 parts of carbonate potash and 50 parts of glycerine. This solution is non-corrosive and will remain perfectly liquid at all temperatures above its congealing point. J. C.

### 138. CEMENT FOR LEATHER AND IRON.

To face a cast iron pulley with leather apply acetic acid to the face of the pulley with a brush which will roughen it by rusting, and then when dry apply a cement made of 1 pound of fish glue and ½ pound of common glue, melted in a mixture of alcohol and water. The leather should then be placed on the pulley and dried under pressure. R. M.

### 139. WHITE WRITING FLUID FOR BLUE-PRINTS.

A fluid which I find is as good as any I have ever used for writing white on blue-prints is made of equal parts of sal-soda and water. Another fluid, not as good, is made by mixing equal parts of borax and water. Both these fluids must be used with a fine-pointed pen; a pen with a blunt point will not work well. C. W. MORRISON.

Allegheny, Pa.

### 140. WATERPROOF PAINT FOR PLASTER.

To make waterproof paint for plaster get some mica plates, bleach them by fire, boil in hydrochloric acid, wash and dry and reduce to a fine powder; then mix with sufficient quantity of collodion to make it run from the brush. Apply with ordinary paint brush. F. L. ENGEL.

New Britain, Conn.

### 141. RE-INKING TIME-CLOCK RIBBONS.

For re-inking time-clock ribbons we use the following receipt for black: 1 ounce aniline black; 15 ounces pure grain alcohol; 15 ounces concentrated glycerine. Dissolve the aniline black in the alcohol and then add the glycerine. For blue use prussian blue, and for red use red lead instead of the aniline black. This ink is also good for rubber stamp pads.

Moline, Ill. ALBERT D. KNAUEL.

### 142. TO SCALE CAST IRON.

To remove the scale from cast iron use a solution of 1 part vitriol and 2 parts water; after mixing, apply to the scale with a cloth rolled in the form of a brush, using enough to wet the surface well. After 8 or 10 hours wash off with water, when the hard scaly surface will be completely removed.

Schenectady, N. Y. R. B. CASEY.

### 143. TO FASTEN RUBBER TO WOOD.

Make a cement by macerating virgin gum rubber, or as pure rubber as can be had, cut in small pieces, in just enough naphtha or gasoline to cover it. Let it stand in a very tightly corked or sealed jar for fourteen days, or a sufficient time to become dissolved, shaking the mixture daily.

Another cement is made by dissolving pulverized gum shellac, 1 ounce, in 9½ ounces of strong ammonia. This of course must be kept tightly corked. It will not be as elastic as the first preparation. OSCAR E. PERRIGO.

Neponset, Mass.

### 144. MARKING POLISHED STEEL.

A very handy way of marking polished steel for sizes, instructions, etc., is to keep a small oil can filled with turpentine with which to saturate a small piece of waste as needed; rub over the surface to be marked and then do the marking with an indelible copying pencil, which will show up very plain. Of course the can of turpentine also comes in handy to use for drilling hard steel, springs, etc.

St. Paul, Minn. ARTHUR MUNCH.

### 145. TO BLACKEN ZINC FOR LAYING OUT.

This receipt of course is the same as that often used for coating iron or steel but it is not generally known among many of the craft that it may be used to prepare zinc for sketching, giving the zinc a dark coating. Dissolve 1 ounce sulphate of copper in 4 ounces water, add ½ teaspoonful of nitric acid and apply a thin coating to the zinc with a piece of waste. If used for iron or steel the work should then be rubbed dry. Care should be taken in handling and using the mixture, as it rusts iron and steel badly if left on. R. M.

### 146. TO CLEAN RUSTED STEEL—TO PRESERVE STEEL FROM RUST.

Rusted steel can be cleaned by brushing with a paste compound of ½ ounce of cyanide potassium, ½ ounce castile soap, 1 ounce whiting, and water sufficient to form a paste. The steel should be washed with a solution of ½ ounce cyanide potassium in 2 ounces water.

To preserve steel from rust dissolve 1 part caoutchouc and 16 parts turpentine with a gentle heat, then add 8 parts boiled oil, and mix by bringing them to the heat of boiling water. Apply to the steel with a brush, the same as varnish. It can be removed again with a cloth soaked in turpentine.

New Haven, Conn. A. L. MONRAD.

### 147. ALLOYS FOR DRAWING COLORS ON STEEL.

Alloys of various composition are successfully used for drawing colors on steel. To draw to a straw color use 2 parts of lead and 1 part of tin, and melt in an iron ladle. Hold the steel piece to be drawn in the alloy as it melts and it will turn to straw color. This mixture melts at a temperature of about 437 degrees F. For darker yellow, use 9 parts of lead to 4 parts of tin, which melts at 458 degrees F. For purple, use 3 parts of lead to 1 part of tin, the melting temperature being 482 degrees F. For violet, use 9 parts of lead to 2 parts of tin which melts at 594 degrees F. Lead without any alloy will draw steel to a dark blue. The above apply to steel only since iron requires a somewhat greater heat and is more or less uncertain in handling. MAX DEHNE.

Cleveland, Ohio.

### 148. FOR CHAPPED HANDS—EYE WASH.

I noticed a receipt for a cure for chapped hands, in the December MACHINERY. This may be good but as glycerine is bad for the skin of many people, when used for such purposes I herewith give you a receipt which I believe will be found more generally satisfactory, as it contains less glycerine. I worked in a drug store for several years and tried many combinations for chapped hands and finally selected the following: Bay rum, 3 ounces; glycerine, 1 ounce; carbolic acid, ½ drachm (30 drops). Wash the hands well and apply while hands are soft, preferably just before going to bed. *Rub in thoroughly.* This rarely fails to cure the worst "chaps" in two nights.

Also a most excellent eye wash is as follows: boric acid, 40 grains; camphor water and distilled water, each 2 ounces. Bathe the eyes freely several times a day. This is handy to have when the eyes are inflamed from having steel or emery, etc., in them. GEORGE C. NASH.

Rockford, Ill.

* * *

One of the big steel manufacturers at Sheffield, Eng., is said to be exhibiting a knife with 75 blades, some scene about Sheffield engraved on each blade. The firm has a standing offer of $75 to any one who can shut all the blades of this highly useful tool without cutting his fingers.

# HOW AND WHY.

**A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.**

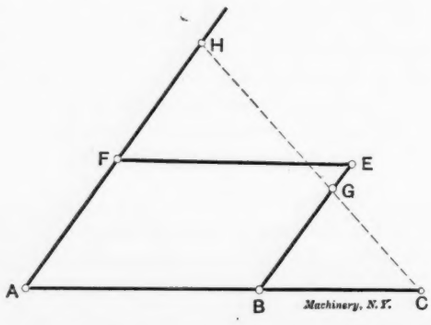
**Give all details and name and address. The latter are for our own convenience and will not be published.**

9.—Steel. Are the arms of a flywheel or gear any less likely to break from the shrinkage of the casting if it is made with five or seven arms or spokes, instead of six?

A.—Other conditions being the same there should be no difference, because the stresses caused by shrinkage are radial and are resisted by the rim, being normal to it in either case. For this reason an odd number of spokes could be no more flexible in adjusting to the shrinkage than an even number, as with either an odd or even number the hub must remain in the center.

10.—L. B. O.—Can you give us any information in regard to the pantograph and its application to machinery?

A.—The pantograph consists of 4 links forming a parallelogram having opposite sides equal. One side, $A\,B$, is extended to some convenient point as $C$, which is the pivot point. The adjacent side, $A\,F$, is also extended and serves as a handle by which the pantograph can be moved into any desired position about its pivot, $C$. Pencils at points $H$ and $G$ respectively will trace similar figures, which, however, will be unequal in size. These points are located upon a straight line extending




from $C$ to $H$, as shown dotted in the figure. The principle of the pantograph depends upon the fact that triangles $C\,B\,G$ and $C\,A\,H$ are similar triangles and that they will remain similar whatever the position of the pantograph may be. This being the case the distances of points $H$ and $G$ from pivot $C$ will always be in the same ratio and the figures traced will necessarily be the same. The pantograph is the familiar device used by draftsmen for reproducing illustrations on a different scale from the original and is also employed in routing and engraving machines, for indicator reducing motions, etc.

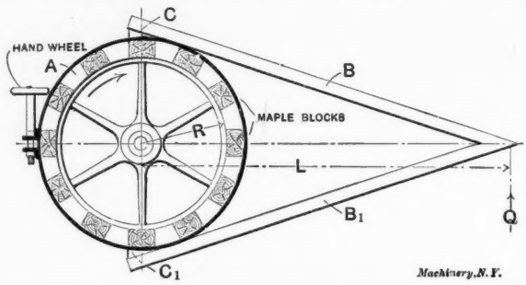
11. J. H. K.—I wish to make some small aluminum castings. They are not very regular in shape, being thinner in some parts than others. I have been making them but they don't turn out just as satisfactory as they should. I use a metal mold, but while the mold is quite smooth the castings come out pitted which is not very desirable as they must be highly finished. On this occasion I am limited to weight, therefore I cannot alloy the aluminum as it will make the castings too heavy. Please state which is the best kind of metal for the molds, also the best furnace. Must I use a crucible to get best results? In fact I would like to have the information on the best practice.

Answered by Dr. Richard Moldenke.

As your correspondent cannot alloy his aluminum, his attention should be directed as much as possible to keep the metal from burning influences. Hence he should use the crucible altogether, as in this way he keeps his metal from contact with fuel or gases. Aluminum castings should be poured as cold as they will run properly to get the best results, but as in this case the work is light and therefore has to be run quite hot, it would be good to heat up the metal molds, if this can be done conveniently. As a general proposition, a metal mold should be as nearly the same in composition as the metal to be cast into it, the necessary precaution being taken to alloy with enough of other metals to get the melting point of the mold higher. In this case an alloy of aluminum with some copper would do all right. Cast iron can be used very well, however, without difficulty, as the castings are small and the contraction will be a small matter to deal with. Hence the use of the crucible well protected by charcoal on the metal, the heating up of the molds, and the pouring of the metal as cold as it will run well, should help your correspondent to better results.

12. E. H. N.—Give a formula for finding the pressure to be applied to a brake band to hold a known load at a radius of 5 feet 3 inches (63.02 inches exactly) as in the case of the Prony brake. The brake wheel is 20 inches outside diameter and 6 inches face. The band is lined with maple wood shoes, slash grain, and we intend to cool the brake wheel with water on the inside and to use tallow for lubricating the blocks. The shoes are riveted to a band which is drawn together on the wheel by means of a hand wheel and screw.

A. A formula for giving the necessary tension in the band of a Prony brake is given in Jones' Machine Design, Part II. It is only to be used, however, when the arms, $BB_1$, are attached to the brake band, $A$, at $C$ and $C_1$, diametrically oppo-




site, or 180 degrees apart. It is only when attached at these points that a practical working formula, it is asserted, can be employed, for the elasticity of the materials makes the result uncertain for other positions of attachment of the arms. The formula is as follows:

$$T = \frac{Q\,L\,10^{.00758\,\mu\,180}}{2\,R\,10^{.00758\,\mu\,180}}$$

In simple form, but applicable only with the points of attachment 180 degrees apart, it is:

$$T = \frac{Q\,L\,10^{1.3664\,\mu}}{2\,R\,10^{1.3664\,\mu} - 1},$$

in which

$T$ = greatest tension in brake band.
$Q$ = force applied at end of brake to resist its rotation.
$L$ = distance from center of drum to line of action of $Q$.
$R$ = radius of brake drum.
$\mu$ = coefficient of friction.
$\pi = 3.1416$.

For example, if the load at the end of a lever arm 5 feet 3 inches or 63 inches were 150 pounds; the coefficient of friction 150 pounds; and the coefficient of friction 0.1, which would apply for the conditions given, the tension would be

$$T = \frac{150 \times 63 \times 10^{.13664}}{2 \times 14 \times 10^{.13664} - 1} = 1.252 \text{ pounds.}$$

If it is assumed that the coefficient of friction is, in general, 0.1, the formula may be expressed in the simpler form,

$$T = \frac{1.165\,Q\,L}{2\,\pi R\,\mu},$$

in which the literal quantities have the same values as above.

* * *

Apropos of the receipts for blackening sheet tin or zinc for template work, which have been given recently, it may be profitably mentioned that zinc can be blackened by the use of chloride of antimony dissolved in muriatic acid. Just sufficient muriatic acid is added to the chloride of antimony to dissolve it, and the solution obtained is diluted with 20 parts of grain alcohol. It is applied to the zinc with a brush or by dipping. Care should be taken that the solution is not too strong in acid, as it will not work properly and the coating will not adhere.

# MACHINERY AND TOOLS.

## A MONTHLY RECORD OF NEW APPLIANCES FOR THE SHOP.

### LATHE ATTACHMENT FOR BORING.

This tool has been designed to facilitate the operation of boring in the lathe and will take the place of a boring mill in a satisfactory way within its range. As shown in Figs. 1 and 2, it consists of a housing or bracket carrying a vertical slide, bolted to the rear of the carriage, and a knee adapted to slide thereon for carrying the work. The raising or lowering of this knee is done by the crank and screw on the rear standard. After adjusting the knee to suit the height of the work being done, it may be clamped in place at the front end by the bolts which slide in the solid brackets shown in Fig. 2. Not only is the clamping surface of the knee planed true with

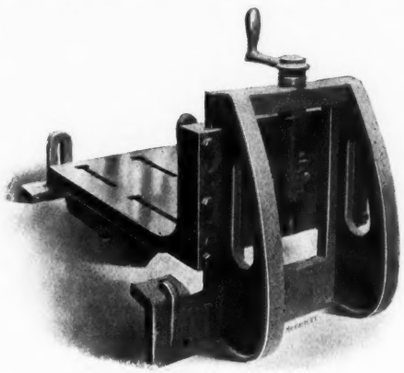


Fig. 1. Lathe Attachment for Boring.

the spindle, but the upright surface at the rear is also squared to allow its use as a gage surface in setting the work parallel to the axis of the lathe.

This device obviously does away with the necessity for blocking up the work, which occurs when trying to use a boring bar in the lathe without special holding arrangements. To get the full capacity of the machine, the makers, H. B.

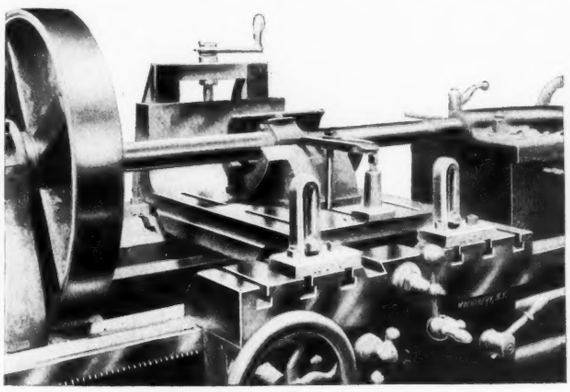


Fig. 2. Boring Attachment in use.

Underwood & Co., 1025 Hamilton St., Philadelphia, Pa., advise that, instead of mounting the boring bar on the centers, it be held in a bearing clamped to the faceplate and revolving at the rear end in a center rest. This will allow much heavier cuts to be taken than will be possible when the bar is mounted on centers in the usual way.

### PRATT & WHITNEY TURRET LATHE AS ADAPTED TO FINISHING CASTINGS.

The two accompanying half-tones show the well-known Pratt & Whitney turret lathe adapted to the finishing of gasoline engine cylinders. The nearer view, Fig. 2, shows a casting in place in the special chuck used on this job. As may be seen, the operation consists of finishing the bore and turning the collar and the flange at the lower end of the cylinder. The construction of the chuck is such that each cylinder is held at eight points. Two clamps are used, each of which has two points of contact with the work, and these in combination with the four opposed fixed contacts, are sufficient to clamp the work firmly without springing it as would be the case if a lesser number of gripping points were used.

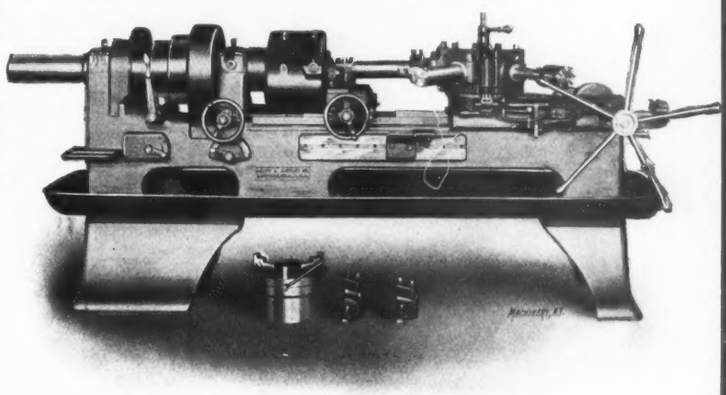


Fig. 1. Turret Lathe Rigged for Boring Gas Engine Cylinders.

The turret carries a series of boring tools and reamers. One of the boring tools carries on its shank a tool holder for finishing the collar at the base of the casting, as may be seen in Fig. 1. The finishing reamer is of the inserted tooth expansible type, and is held in a floating holder. Cross slide tools are provided for finishing the flange, these tools being independent of the turret in all their functions, so that the two slides may be used together.

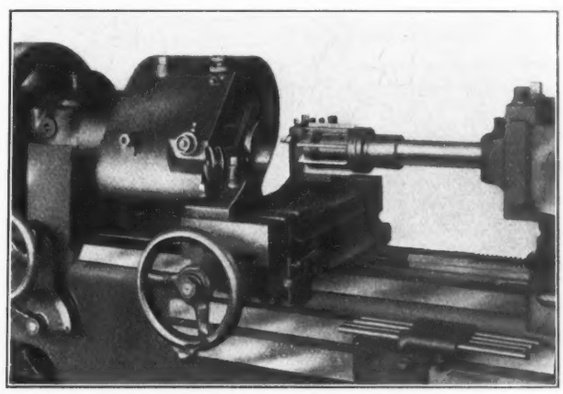


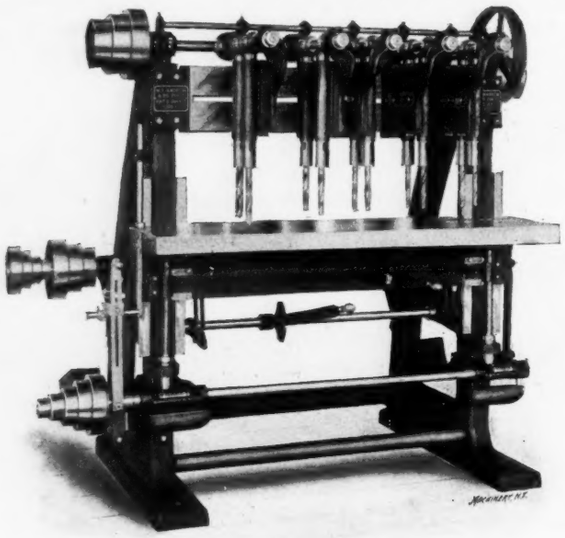
Fig. 2. Chuck and Tools for Gas Engine Cylinders.

There are numerous applications for this particular machine in automobile work. Where manufacturers have insufficient work to keep the machine constantly at work on castings, it is advisable to have it equipped with the rod feed and collet mechanism, thus permitting rod work also to be handled. Quotations and detail specifications covering work of this kind will be furnished upon application to the makers, the Pratt & Whitney Co., Hartford, Conn.

### MULTIPLE DRILLING MACHINE.

The machine shown in the accompanying half tone differs from the usual construction of machines of this type in being provided with two spindles on each head. Both of them are adjustable at right angles to the face of the cross rail. They are driven from a horizontal shaft through a series of bevel gears. The feed is applied to the table, which is raised by screws at each end; an adjustable automatic stop throwing out the feed at any desired point. The horizontal lever seen under the platen is then operated to open the half nuts through which the table is fed, and the platen may be lowered by the lever attached to the rockshaft underneath the machine. The table is counterbalanced by adjustable weights.

All the spindles, which are made to take Morse taper shanks, are adjustable, and can be set as close as 3 inches center to center or up to 42 inches apart center to center, lengthwise of the rail; and they may also be staggered across the table from 0 to 7 inches. There are four changes of feed and the machine has sufficient power to drive 10 drills of from ⅛ to ¾ inch

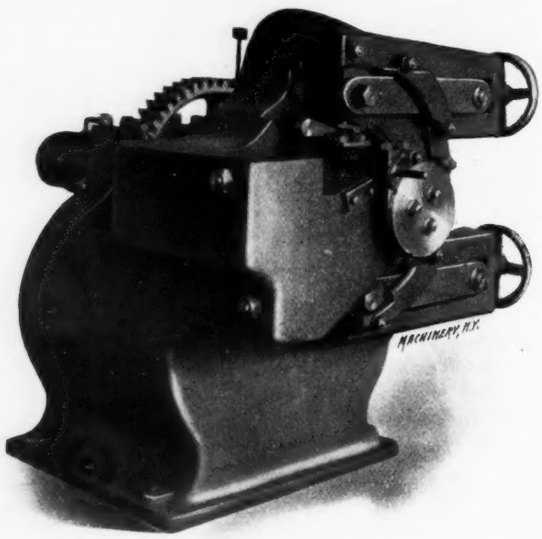


Andrew Multiple Spindle Drill.

diameter in steel or iron. Other sizes are made which will drill as close as one inch center to center, and up to 12 feet between centers of outside spindles. M. L. Andrews & Co., Cincinnati, Ohio, are the builders of this machine.

## ROTARY THREAD ROLLING MACHINE.

The Acme Machinery Co., Cleveland, Ohio, have recently designed the rotary thread rolling machine shown in the half-tone below. In this machine the threading dies, instead of being of the reciprocating type, are composed of one rotary or revolving die which runs continuously in one direction,




Rotary Thread-rolling Machine.

and one segmental die which remains stationary after it is adjusted to the job. The bolt or piece that is to have the thread rolled on it is placed between the two threading dies and carried around with the rotating die, which is mounted on the main shaft or spindle. The segmental die is carried in a heavy block which is eccentric to the shaft and by loosening one of the hand wheels and tightening the other it is advanced or withdrawn to vary the distance between it and the rotary member. The feeding is done by an oscillating carriage, seen plainly at the front end of the spindle. This carriage is operated by dropping a pawl into connection with a notched disk which moves the carriage with the work forward into the radius of action of the dies. The jaws which carry the work then open automatically and allow the carriage to drop back by its weight to the feeding position again. These machines are made in two sizes. The one-inch machine is furnished with countershaft, wrenches, and five pairs of dies, weighs 10,000 pounds and occupies a floor space of 4 feet 10 inches by 6 feet 6 inches. The two-inch machine is similarly equipped, weighs 20,000 pounds and occupies a floor space of about 7 feet by 9 feet.

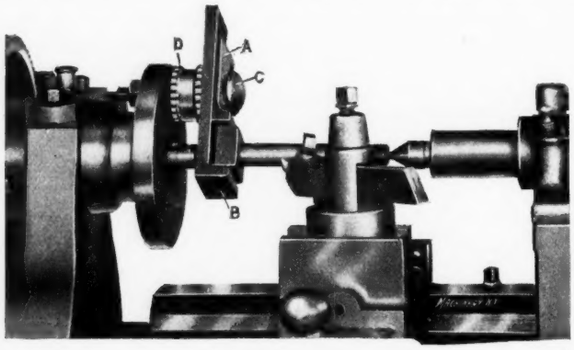
## MULTIPLE DRILLING ATTACHMENT.

The drilling attachment shown in the accompanying half-tone is designed for finishing a number of holes at one time without making any change in the drill press used and without reversing the rotation of the spindle. The drills, of which three are used in the case illustrated, are driven by straight spur gears throughout in the larger sizes and by an internal gear in the smaller sizes. These gears are wholly or partially encased according to the size of the device and the conditions of the work. The attachment is so designed as to make the bearings as large and as long, and give the gears as coarse a pitch as is practicable. The device is applicable to any case where two or more holes are to be drilled in constant relation to each other, such as drilling cylinder heads for small engines and pumps, or for any special work where quantity is to be considered. The spindles are not adjustable, but the normal cost is low enough so that one or more can be installed to suit different dimensions. The makers, The Francis Reed Co., of 43 Hammond St., Worcester, Mass., furnish it complete, to order only, according to specifications fitting it to the class of work it is designed for.

Multiple Drilling Attachment.

## ARMSTRONG BOLT DRIVER.

The device shown in Fig. 1 has been devised and is being put on the market by Armstrong Bros. Tool Co., Chicago, Ill. The cut shows quite plainly the way in which the device is used. It consists essentially of two jaws, *A* and *B*, which are provided with minute serrations on the two surfaces which come in contact. These jaws are held together and clamped to the faceplate of the lathe by a bolt, *C*. The washer, *D*, holds the device far enough away from the face plate to allow the point of the live center to project through the lower jaw into the center hole of the bolt which is being turned. Both

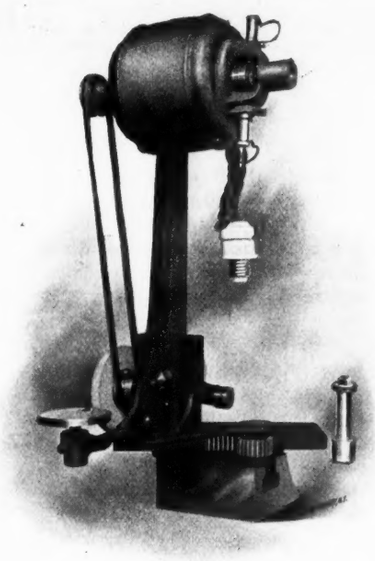



Armstrong Bolt Driver.

of the jaws are slotted so they may be adjusted to fit any size of bolt within their range and be used on any diameter of faceplate as well. The device is made in three sizes having capacities for 2-inch, 3-inch and 4-inch stock, respectively. It is not, of course, limited in its application to the turning of square and hex-headed bolts, but may be used as well for square or rectangular bar stock, or for irregular forgings which present suitable driving surfaces. The washer, *D*, is extensible to permit the use of the tool with centers of varying lengths. The parts are drop forged throughout.

### THE MUELLER GRINDING ATTACHMENT.

The device shown herewith is intended to be used in lathe tool posts (or in connection with other machines) for truing up the centers, for grinding work held between the centers, or for facing and doing internal work in the chuck or on the faceplate. Power is furnished to the motor from the ordinary incandescent lamp socket. From the motor the wheel is driven by a round belt. The wheel spindle, the bearings of which are adjustable to take up wear, can be located at the proper height to bring it in line with the center line of the lathe. For truing up centers the rack and pinion shown give a movement to the wheel at an angle of 30 degrees with the line of the spindle, thus grinding all centers to an exact 60-



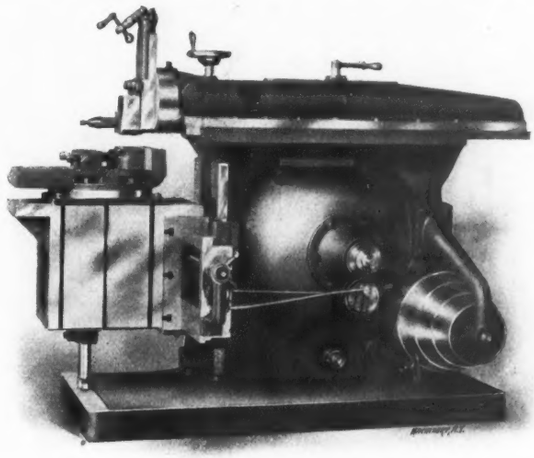
The Mueller Grinding Attachment.

degree angle without the use of a compound rest. For internal grinding the extension arbor shown at the right is used in place of the large wheel. The arrangement may be used independently of the lathe for sharpening cutters, saws, etc., and a rest for this purpose is provided. Provision is made for taking up the slack of the endless belt and for keeping the dust and emery away from the bearings of the spindle. This device is made by the Mueller Machine Tool Co., Cincinnati, Ohio.

### THE CINCINNATI RAILROAD AND MANUFACTURING SHAPER.

The Cincinnati Shaper Co., Cincinnati, Ohio, are making the shaper shown in the accompanying half-tone. The gearing and drive of this machine have been proportioned with the intention of making it the most powerful shaper of its stroke on the market, and of course the frame, slides, etc., have been strengthened to correspond. The column, ram, and rail, are all unusually heavy and made of suitable form to withstand the strains to which they are subjected. The main gear journal has two diameters, the inner end being twice that of the outer end, thus overcoming any tendency to break at the junction of the gear. There is also a third or outer bearing to the cone shaft. The crank block is a steel casting and is set well into the cup of the gear, thus permitting the rocker arm to travel close to the edge of the rim, avoiding the usual overhang. Ram, head, rail, apron and crank wheel slides are fitted with full length taper gibs throughout, adjustable endwise by single screws, this being preferable to gibs with setscrews impinging with various pressures at the several points in the length of the gib. An outer support for the table is furnished with each machine without extra charge. The vise has a graduated swiveling base with jaw plates of annealed tool steel, and is set up by a double screw arrangement. Shafts are of high-carbon steel, gears are cut from the solid, flat siding surfaces, are all hand scraped, and all pinions are of cast steel.

Changes and adjustments for the length of the stroke, the position of the ram, the height of the table, etc., may be made while the machine is in motion. A number of extra attach-



Cincinnati Heavy-duty Shaper.

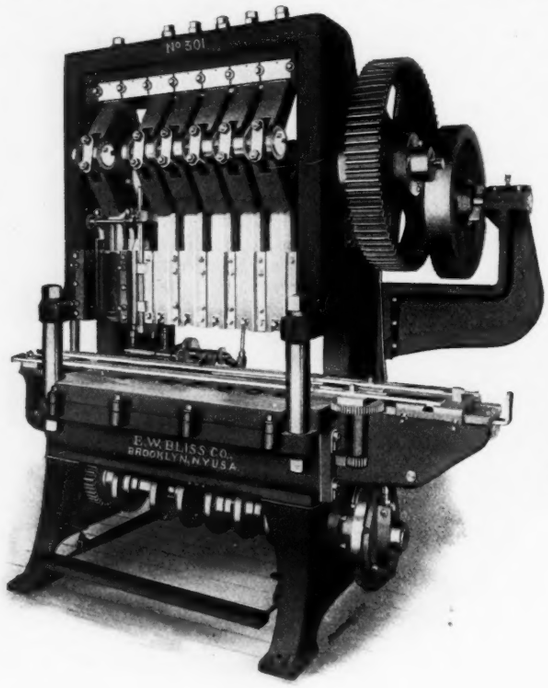
ments may be furnished when desired, such as power down feet, revolving table, tilting table, concave attachment, motor and gear-box drives; the machine may also be had in either the single or back-geared form, the ratio of gearing being in the one case 7.2 revolutions of the shaft to one stroke of the ram, and in the other 30 to 1. The machine shown has a 33-inch stroke with 15-inch vertical travel of table and 32 inches horizontal travel. The top of the table has a surface of 16 inches wide by 30 inches long. It will take a tool with a 1 x 2¼ inches shank and will key seat a 4-inch shaft. The net weight of the machine is about 6,300 pounds.

### BLISS AUTOMATIC MULTIPLE SLIDE PRESS.

The press illustrated in the cut is of recent design, and is intended to work continuously on products such as lamp parts, etc. It has a double action cutting and drawing slide with a lift-out, also five single action cutting and forming slides, each having an independent lift-out. The press is fitted with an automatic roll feed which takes the stock from the reel; also a grip and carrying feed which carries the first operation cup or shell from one to another of the five single action slides. The number of single action slides may be lessened or increased as the nature of the work demands.

Each slide has its own adjustment, shown at the top of the press, as well as its own gibbing device. This makes the press particularly adapted for the manufacture of such articles as lamp burner parts and similar pieces which are cut and formed, pierced, trimmed, stamped and finished in several successive operations, since a light operation with delicate dies is thus not thrown out of alignment by a heavy adjoining operation. The press is run at from 35 to 50 strokes per minute, and with six slides as shown, it will produce from 210 to 300 operations per minute, without requiring any intermediate handling. Provision is made for rapidly adjusting the feed and working parts from one size to another. The number of operations that may be performed by this process is limited only to the number that may be done without annealing. Where annealing is essential it is sometimes advantageous to draw the first operation in a plain press, after which the cup or shell is annealed. The roll feed on the automatic press is done away with in this instance and a dial feed substituted, on which the first operation shell is placed and

from which it is carried by the lateral feeding device the same as when it is used in connection with the roll feed. The rolls on the press illustrated will feed up to 5 inches long and up to 5 inches wide, making the largest permissible diameter of trimmed edge on the die approximately 5 inches. The stroke of the outer double action slide is 2 inches, while the




Multiple Slide Press.

stroke of the inner double action slide is 4 inches, as are also the strokes of the single action slides. The total weight of the press, as illustrated, is 12,500 pounds. It is one of the products of the E. W. Bliss Company, 5 Adams Street, Brooklyn, N. Y.

## A NEW HIGH PRESSURE BLOWER.

The machine which is illustrated in the accompanying cuts is a blower designed primarily for furnishing a blast of air at high pressure for melting iron in the foundry cupola. This blower involves in its design and method of operation some very ingenious ideas, and its construction is worth describing in detail.

A description will first be given of the various parts which go to make up the blower. Fig. 2 shows the frame or casing. It consists, as may be seen, of two interesecting cylinders with ports at each side. This casing is accurately bored and faced and has its intakes and discharge openings flanged and tapped for standard pipe fittings. The small and medium sizes are built like the one shown, but for the heavier machines the two axes of the casing lie in the same horizontal plane and the intake and discharge are at the top and bottom of the casing. To the faces of the lower flanges of the casing at either end are bolted the two cover plates shown in Fig. 3. These cover plates have large inwardly extending hubs which form the inner boundaries of the air chambers, as may be seen in the line drawings, Figs. 6, 7 and 8. These hubs, however, do not support the central shaft or come in contact with it, being used merely as filling pieces in the interior of the chamber. In the sides of the cover plate are leakage chambers as they may be called, which perform the double function of lessening the leakage and preventing noise as well, as will be explained when the operation of the machine is considered. Brackets are cast to the cover plates to form the outboard bearings of the shaft which carries the impeller. This impeller, shown in Fig. 4, does the real work of compression. It consists of a disc mounted in the center of the shaft, carrying three diamond-shaped bars. This disc fills the space between the ends of the two hubs on the covered plates shown in Fig. 3 which come closer together than is shown in the cut, and leave just room for it to revolve with a reasonable amount of clearance. The impeller bars, as may be seen in the line drawings, span the distance between the interior hub and the external casing and thus force the air through the machine as they revolve. Within the upper part of the casing revolves the idler shown in Fig. 5. This is a symmetrical casting and has a periphery which is nearly a complete circle. It consists of three blades cast in one piece with the shaft, is very rigid, and is rotated by gearing. It is revolved at the same speed as the impeller in the lower part of the casing. These rotating parts are all

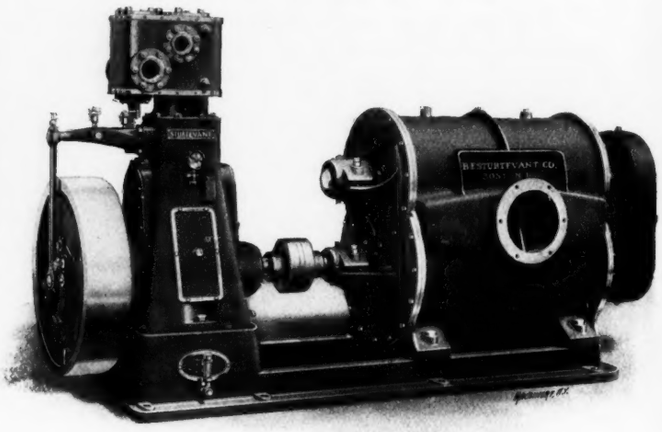


Fig. 1. Sturtevant High.pressure Blower.

symmetrical and are all given considerable clearance, so that no obstacle is offered to the use of high speeds in the operation of the blower. Between the idler and impeller the space is so great that not even an excessive variation in the accurate running of the gears will allow the two rotors to come in contact. This clearance is at least ⅛ inch in the smallest blowers, and in the larger sizes ranges from ½ to ¾ inch. The gears which rotate the idler run in oil and are encased for protection against dirt and accident.

The line cuts, Figs. 6, 7 and 8 will explain the operation of the machine. In Fig. 6, *A*, *B*, and *C* are the impeller blades, *D*, *E*, and *F* are the spaces between them, *X*, *Y*, and *Z* are corresponding chambers formed between the vanes of the idler, and *L*, *M*, *N*, and *O* are leakage spaces in the upper and lower

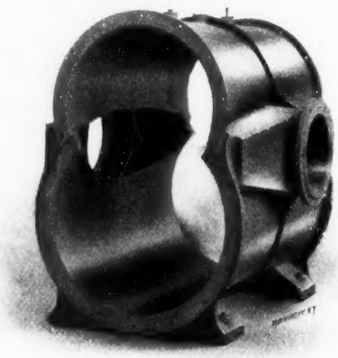


Fig. 2. The Frame or Casing

covers of the casing. The impeller blades are revolving in the direction shown by the arrows so that the intake is at the left and the discharge at the right. With the parts in this position chamber *L* is in communication with the atmosphere and chamber *M* is connected with the pressure main, so that the one is under atmospheric pressure while the other has pressure equaling that of the air delivery pipe. In the idler, chambers *X* and *Z* are also connected respectively with the atmosphere and delivery opening, while chamber *Y* is cut off from communication with either. When the parts have rotated a little further to the position shown in Fig. 7 chamber *D* between the impeller blades *A* and *B* has been isolated from communication with either opening while blade *C* has entered

chamber *Z* in the idler. The basic principle on which the mechanism operates will now be apparent. The available volume of chamber *Z* with its inclosed impeller is considerably less than that of chamber *D*, thus, while a certain amount of air is removed from the delivery side as the impeller makes

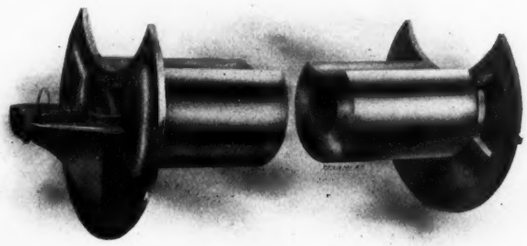


Fig. 3. The Cover Plates.

each third of a revolution, so much more is brought in by the impeller blade that there is a constant flow of air under pressure from the intake to the exhaust.

The air in chamber *Y*, as will be explained later, is at a pressure intermediate between that of *X* and *Z* in Fig. 6. If now, as is about to happen in Fig. 7, communication is suddenly opened between the discharge pipe and chamber *Y*, the greater pressure in the pipe will cause a sudden inrush of air to the space *Y* which will cause a sharp explosion or report something like that which occurs when one bursts a paper bag filled with air. But it will be noted in Fig. 7 that before this can occur clearance or leakage space *O* has opened up communication between *Y* and *Z* in such a way as to gradually bring the pressure in *Y* up to that of the air discharge. It

blowers by gradually reducing the pressure of *Z* to nearly that of the atmosphere. A further movement of the machine brings impeller *C* out in front of the inlet pipe to a position corresponding to that of *A* in Fig. 6. Spaces *L* and *M* in the lower cover perform similar functions to *N* and *O* so far as rendering the machine more nearly noiseless is concerned. With the machines operating in the direction indicated, *M* is the only one which has any effect, chamber *L* being provided only to make the mechanism symmetrical so that it may be run in the opposite direction if desired. If this were done *L* would be operative and *M* idle. In Fig. 8 it will be seen that impeller *B* is about to move forward to a position where passage *M* will open up communication between high pressure space *E*

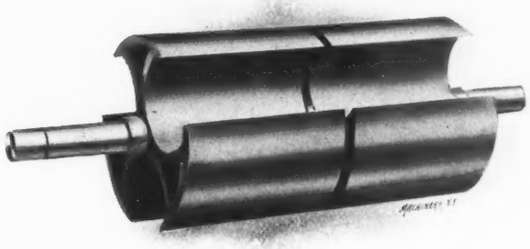


Fig. 5. The Idler.

and the atmospheric pressure in chamber *D*. This serves, as in the case of the passages above, to gradually bring the pressure in the two chambers to equilibrium instead of suddenly opening up communication between them. To carry out this purpose still further it will be noted in Fig. 2 that the inlet

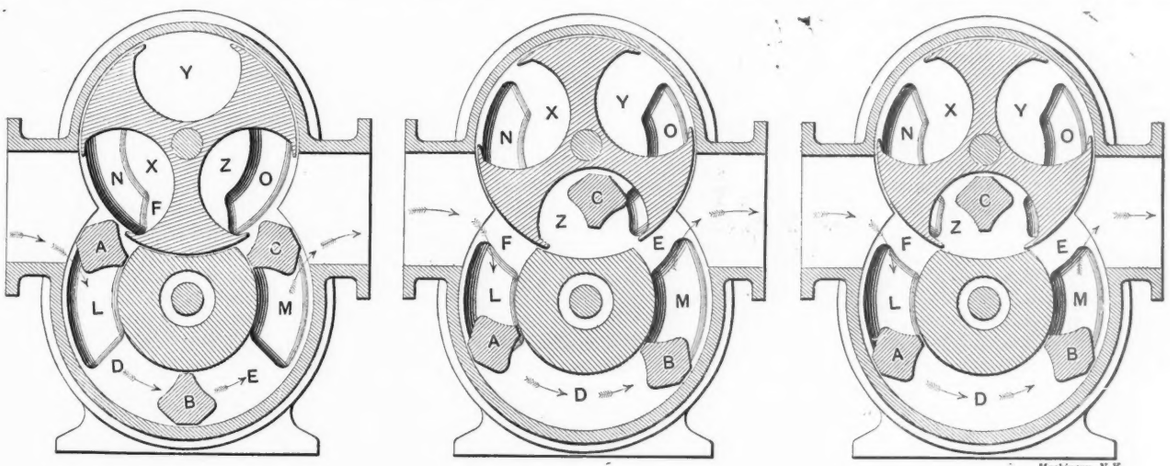



Fig 6 Fig 7. Fig. 8.

Cycle of Operation in One-third Revolution.

also serves in some measure to reduce the pressure in *Z* and thus reduce the amount of air which is lost by being carried back under the pressure to the inlet. In Fig. 8 this idea is carried still further and a second leakage chamber *N* is used to save some of the high pressure air in chamber *Z* by transfering it to *X* through leakage passage *N*. This again serves to reduce the noise which is a feature of the operation of many

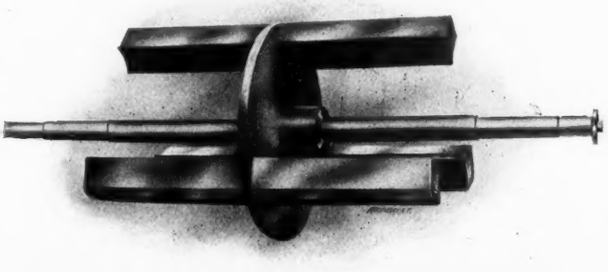


Fig. 4. The Impeller.

and discharge ports have a diamond shape outline while the impeller and idler vanes are rectilinear, thus communication is opened more gradually than would be the case if the outlines of both were parallel.

The B. F. Sturtevant Co., of Boston, who manufacture this blower, build it in sizes for use with cupolas melting from one to thirty tons of iron per hour. This is based on the assumption, which appears to be sustained in practice, that about 30,000 cubic feet of air are required to melt a ton of iron. The blower runs at from 200 to 450 revolutions per minute, depending on its size. The pressure of the air delivered depends on the resistance offered to its free escape.

## A MULTIPLE SPINDLE AUTOMATIC SCREW MACHINE.

Figs. 1, 2 and 3 show front elevation and cross sections of a recently designed automatic screw machine; as may be seen it is of the multiple-spindle type in which the tools are held in a circular row of holes in a knee or slide which feeds them to the work, while the bars of stock are held in rotating spindles which may be indexed to bring them successively opposite the various tools which act upon them. At the right-hand end of the machine in Fig. 1 will be seen the two pul-

leys by which the spindles in the rotating head are driven. The outer and larger of these drives a shaft which extends the length of the machine and rotates the work spindles for threading. The smaller and inner pulley is connected to a sleeve which encircles the shaft before described, and from this rotating sleeve the spindles derive their movement for turning, cutting off, etc.

Fig. 2 will show the way in which the spindles are driven. The outer end of the spindle is here shown broken off; the stock-feeding spool and the jaws for operating the spring collet are of the construction used in practically all automatic screw machines and therefore need not be particularly described. Only one of the five spindles contained in the revolving head is shown in the cut. Gear *K* is keyed to the center sleeve *M*, driven by the smaller of the two driving pulleys before mentioned, while gear *N* is fastened in a like manner to center shaft *O*, which runs in the other direction. These two gears run respectively their mating gears, *L* and *S*, which are loose on bronze sleeve, *Q*. Between them is a clutch cone, *P*, which is keyed to the spindle *R* through the bronze sleeve, and may be thrown into engagement with either one of them by means of yoke *T*, which is pivoted in spider *U* and is operated by a lever actuated from one of the cam drums. When this lever is thrown to the right cone *P* connects gear *L* with the spindle and the work revolves in one direction for turning etc. When yoke *T* is thrown the opposite way a spring clutch pin connects the spindle with the other gear *S*, so that the work is reversed for threading. Three springs, *V*, located

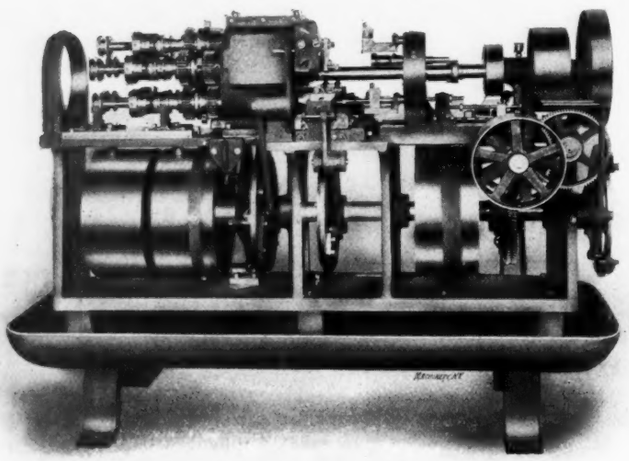


Fig. 1. Multiple Spindle Automatic Screw Machine.

in drill holes in *P*, give the tension for the friction drive, and a pawl, not shown, holds the cone when the block, *W*, is engaged with the spring pin in *P*.

In a machine of this type the keeping of the spindles in alignment at equal distances from each other and the axis of the revolving head is a matter of prime importance. Much depends upon the accuracy of the original workmanship. It is comparatively easy to get the spindles an equal distance from, and parallel to, the center line, within reasonable limits, but to keep them so after the spindles have been running for some time and the boxes have begun to wear is a more difficult matter. Trouble on this score has been minimized in this machine by reversing the usual journal and bearing arrangement. As may be seen, the spindle revolves in taper boxes. These boxes are, however, of hardened and ground steel, while the journal sleeves on the spindle are of phosphor bronze; the wear will thus be evenly distributed on the softer rotating part, while the stationary member on which the alignment depends will be affected to a comparatively slight extent.

Referring again to the half-tone it will be seen that the machine is controlled by a cam shaft running through the base which carries the discs and drums which, with their attached parts, govern the movements of the various slides, spindles, etc. This cam shaft is driven by a quarter-turn belt from the countershaft onto pulleys at the front of the machine, as shown in Fig. 1. There are three pulleys side by side at this

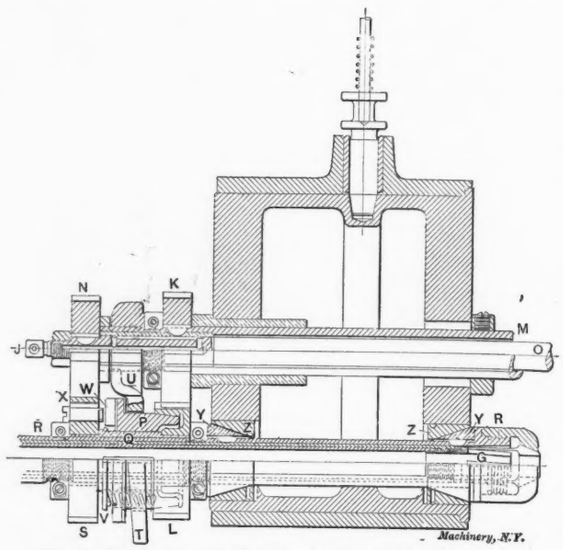



Fig. 2. Section through Spindle showing Driving Mechanism.

point, one each for fast and slow motion, and an idler to which the belt may be shifted when the machine is stopped. The idler is the inside pulley, thus making it possible to operate the machine by hand with the countershaft and the oil pump still running. The belt is shifted from the fast to the slow pulley, or *vice versa*, by dogs on the disk at the extreme right of the machine in Fig. 1. The reduction in speed is made through back gears which may be seen near the pulleys; when these gears are not in use a ratchet arrangement allows them to remain at a standstill. The fast movement is used for all the operating and idle motions of the cam shaft—for everything in fact except the actual feed movements; bringing the tools up to the work, revolving and indexing the spindle head, feeding stock, etc., can all thus be done at a maximum speed irrespective of the slow movement required for feeding.

Looking at Fig. 1 as before, next to the left of the worm wheel by which the cam shaft is rotated comes the drum which actuates the slide to which the box, turning tools, hollow mills, taps or dies, etc., are attached. This is in the

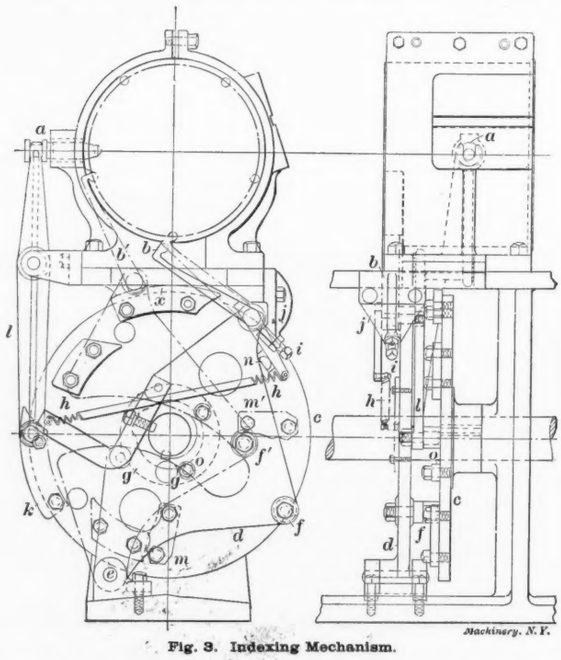



Fig. 3. Indexing Mechanism.

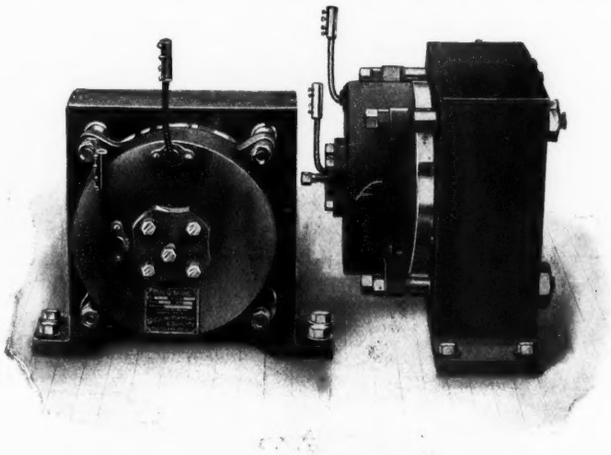
form of a knee with a circle of holes for five tools. A very simple releasing mechanism is provided for use with the tap or die. The arrangement is such that the holder revolves with entire freedom when the thread has been cut to the desired distance.

Next to the cam drum which feeds the turning tools come the cams which operate the two cross slides; these are generally used for forming, or other similar operations, a third slide, mounted on the spindle head, being used for cutting off.

The next mechanism in order, that directly under the cylinder which carries the spindles, is shown more clearly in Fig. 3. These cams, levers, etc., index the spindle cylinder and lock it in position for each new cut. In the rear of the cylinder five holes are drilled near the edge and half way between the spindles. These holes are milled out on an angle of 45 degrees, making a seat for the indexing hook finger, *b*. The finger is shown in three positions and other parts of the mechanism in two positions in the end view. The last positions represent the finger about to be returned for the new indexing. Upon the cam disk, *c*, are bolted the cam strips which control the rocker arm, *d*, by their action on the two rollers, *f* and *g*. This rocker arm is pivoted at *e*. To this arm is also fastened the steel strip, *n*, which carries one end of spring *h*, whose other end is fastened to a continuance of the finger, *b*. In getting a maximum output from the machine it is necessary to reduce the time taken in indexing the spindles to as short a period as possible, and to prolong the life of the machine it should at the same time be done with as little shock as possible. With this end in view the shape of the cam strips which control the indexing is such that the cylinder is started gently from a state of rest, is gradually accelerated to maximum speed, and is then as gradually stopped, bringing it finally to a complete state of rest before the index pin is dropped into place. Finger *b*, being moved by the rocker arm *d* and its cam and rollers, performs the operation of rotating the cylinder. Locking pin *a* being withdrawn by its cam on the disc *c*, arm *e* is thrown to the right. The hook in *b* pulls the cylinder around, bringing it to a stop at the end of its travel when the locking pin is again dropped into position. The fact that pin *b* is limited in its travel by the adjustable screw *i*, which forms the abutment at its heel, makes it possible to stop the cylinder very accurately in the right position, so that the locking pin simply holds it there without having to bring it to the proper location. This makes the wear upon this important part very slight. To withdraw finger *b* from its engaging notch a cam *n*, which is fastened to the inner rim of the cam drum which operates the slide for opening and closing the collet, acts upon the under side of the extension of finger *b*, and tips it out of its seat in the cylinder when the time comes for it to return to its first position.

The drum for collet and wire-feeding mechanism, which is the last in the series, does not differ in its construction and operation from that in ordinary use on machines of this type. The disk next to the indexing mechanism carries dogs which control the action of yoke *T* in Fig. 2, which reverses the spindle at the proper time for threading.

As will be understood from the preceding description, this machine makes a piece complete at each revolution of the spindle. The aim of the designers was to attain simplicity and openness in construction, ease of setting up, elimination of the necessity for constant readjustment, and something better than what had previously been attained in the way of indexing and threading mechanisms, keeping in mind, also, of course, the necessity for turning out accurate work in the shortest possible time. No more tools are required for this machine than for other single spindle machines. On the other hand it is possible to use a great many more tools than on the ordinary type of machine if they are necessary, thus giving it a greater range, and at the same time producing the work more rapidly. This automatic screw machine is the joint product of Mr. Christopher M. Spencer and Mr. R. Hakewessel, both of whom are well known in the screw machine field. It is built by the Universal Machine Screw Co., Hartford, Conn., and can be at present furnished in two sizes, taking work up to ¾ inch in diameter by 5 inches long.



A New Magnetic Brake

## NON-OVERFLOWING PUMP AND TANK.

The accompanying half-tone shows an oil tank and pump made by the Delphos Can Co., Delphos, Ohio, for service in mills, shops, etc., or in any place where receptacles of various sizes are required to be filled with oil. The especial point of interest possessed by this device is the use of the double spout, one side of which is an inlet and the other an outlet. In operation, this double spout is inserted in the mouth of the oiler and the pump operated. The delivery spout is somewhat longer than the return. As soon as the oil level reaches the bottom of the return side of the spout it is siphoned back into the tank as fast as it is delivered. It can be operated in the dark and without soiling the clothing or hands. The tank is made in three, five and ten-gallon sizes. A longer pump is furnished for use with large tanks; in this case the siphoning action is not depended on for bringing the oil back, three pumps being used in all, one of which lifts the oil from the tank, while the other two are used to return the surplus. This device has been on the market a comparatively short time, but has been the subject of numerous repeat orders from customers who have tried it.

Non-overflowing Oil Tank.

## MAGNETIC BRAKE.

In the half-tone below are shown two views of a new magnetic brake. The braking action is obtained by means of a series of plates which are alternately keyed to the shaft and suspended from the frame. The rotating plates are circular in shape and are free to move longitudinally. The stationary members are secured and prevented from rotating by studs at the four corners of the base, being also free, however, to move longitudinally. These are all submerged in a bath of oil, thus keeping the coefficient of friction equal, and making the braking force a definite and constant quantity, besides furnishing a means for carrying away the heat from the friction surfaces and radiating it from the entire exterior of the case. The braking force may be adjusted by screwing in or out the adjusting screw in the center of the spring cover.

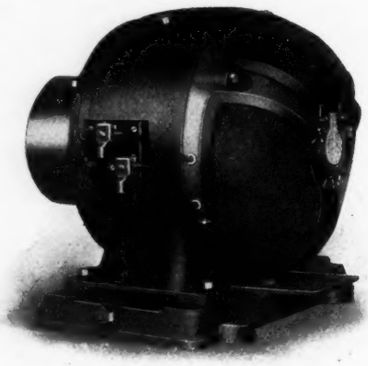
The coil of the magnet is wound thoroughly, insulated and treated with an impregnating process which converts the copper insulation into a solid moisture-proof and heat-conducting mass. The lubricating oil is placed in the case to a depth of ½ inch below the lowest point of the hub opening, and an

oil sling prevents it from escaping. The friction plates throw it to the top of the case, from which it drops to the stationary plates, effectually lubricating them. Weather protection is provided, from the fact that the coil is entirely inclosed, as are also the working parts of the brake. All the parts are machined from jigs and are made on the interchangeable plan. This brake is built by the Electric Controller and Supply Co., Cleveland, Ohio.

### NEW LINE OF SPRAGUE MOTORS.

The Sprague Electric Co., New York, whose round type of motor is well known to users of electrical machinery, has recently developed and put on the market a new line of type D direct-current motors. The half-tone below shows as an example of this line, a motor of the horizontal six-pole semi-enclosed type, with covers held by spring latches.

The yoke is of cast steel, in all sizes except the three largest, where it is made of a good cast iron of uniform quality. The poles are of laminated sheet steel punchings and the field windings are substantially taped, treated with a moisture-proof compound, and baked. These coils are interchangeable. The armature core is also built up of thin notched punchings of special steel selected for its low loss by magnetic hysteresis. These punchings are assembled and keyed on the shaft, or to cast iron spiders, depending on whether the motor has four or six poles. The core is ventilated by transverse air passages which permit a circulation of air through the core windings and commutator. The armature windings are shaped on formers and insulated individually before being assembled on the armature core. Wire bands are used over the end windings to retain them in position. The completed armatures are dipped while hot in an insulating and moisture-proof compound and then thoroughly baked. The commutator is built up of a relatively large number of segments, with windings and brush holders so designed to secure cool operation and give good commutation. The bars, which are of hard, drawn copper segments, are carefully insulated from each other and the clamping rings, by mica insulation of a quality selected to wear evenly with the copper.

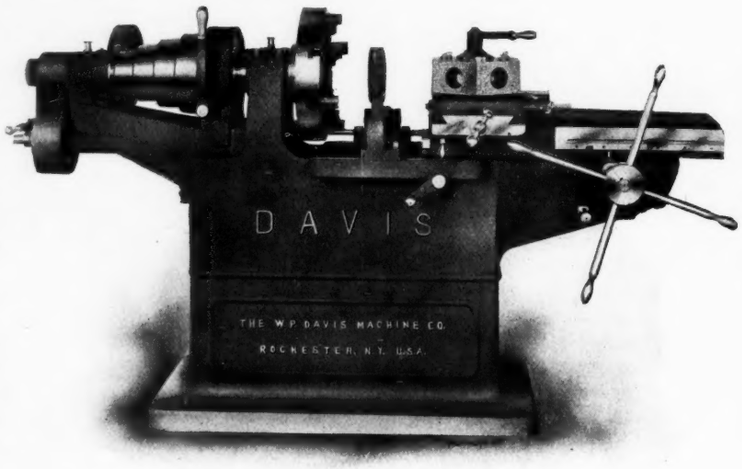


Sprague Type D Direct Current Motor.

These motors may, of course, be built with special frames to suit special conditions. They are made regularly in the open, semi-enclosed, or entirely closed form, with nine different sizes of frames, ranging from 10 horse power to 90 horse power for standard slow speeds, and from 15 horse power to 105 horse power for standard moderate speed motors. They are supplied with either shunt or compound field windings for use on 115, 230 or 500-volt direct-current circuits.

### TWENTY-FOUR INCH BORING LATHE.

The W. P. Davis Machine Co., Rochester, N. Y., have made some recent changes in the design of their turret boring lathe, as may been seen by referring to the accompanying half-tone. The machine is driven by a four-step cone through friction gearing which, in combination with a double speed countershaft, gives a total of sixteen speed variations to the spindle. A 3-inch belt is used. A new feature with this design is the use of a cross slide for carrying the turret, this slide being operated either by hand or by power as may be desired. This feed is used for facing or forming of almost any description by fastening forming tools on the various faces of the turret. There are six changes of feed which may be altered instantly and thrown out automatically. A bushing support is provided between the turret and the chuck for use in steadying boring bars; by loosening a single bolt this may be swung back out of the way when not in use. The machine swings 24 inches, has a 2-inch hole through the spindle, and has a net weight of about 3,200 pounds.




Davis Boring Lathe with Cross Slide.

### BAKER CAR-WHEEL BORING MILL.

Baker Bros., Toledo, Ohio, have recently built a car wheel boring machine which embodies some points of interest. A general idea of its construction may be gained from Fig. 1, which shows it to consist of a rotating table furnished with chuck jaws, a vertical ram for holding a stationary cutter bar, and a supplementary cross slide for facing. This slide is adjustable for height and carries a bushing for supporting the cutter bar. A suitable range of feeds is provided and the ram is fitted with an automatic stop.

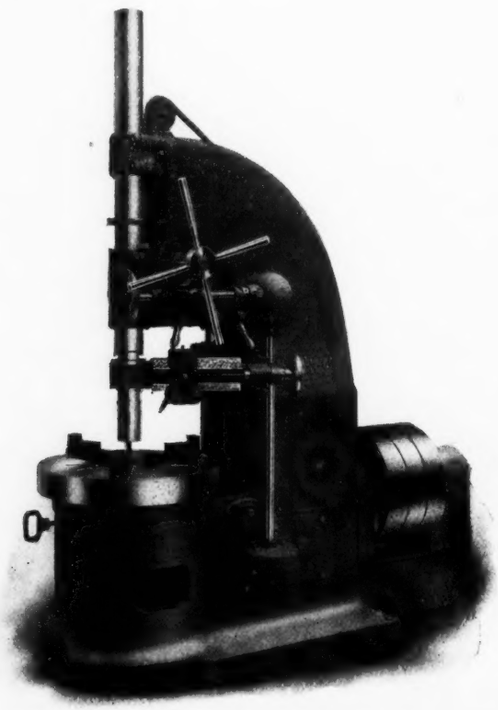


Fig 1. Baker Car-wheel Boring Mill.